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HUGHES
AIRCRAFT COMPANY

ELECTRON DYNAMICS DIVISION

8000H INSTRUMENTATION AMPLIFIER

**OPERATION AND
MAINTENANCE
MANUAL**

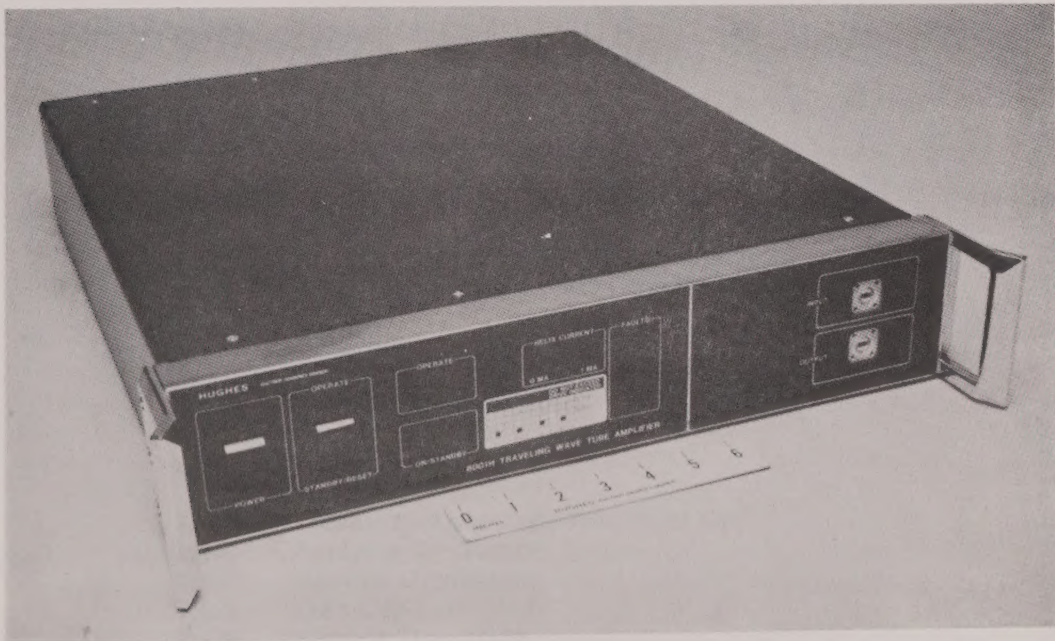
HUGHES AIRCRAFT COMPANY, ELECTRON DYNAMICS DIVISION, JUNE 1989

OPERATION AND MAINTENANCE MANUAL

FOR

8000H INSTRUMENTATION AMPLIFIER

JUNE 1989



**INSTRUMENTATION SERIES
TRAVELING-WAVE TUBE AMPLIFIERS**

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1.0 GENERAL DESCRIPTION

1.1 INTRODUCTION

1.1.1 Purpose of the Equipment

The 8000H Series Instrumentation Amplifiers are broadband laboratory instruments designed for general purpose applications. Each amplifier consists of a traveling-wave tube (TWT) and an efficient solid-state electronic power conditioner (EPC). The RF power outputs of the basic 8000H models are 1, 10, 20, or 30 watts. Modifications are available for special applications as options to the standard models.

1.1.2 Scope of This Manual

This manual describes the standard Instrumentation Amplifier and the options available.

It is concerned with initial installation and operation of the amplifiers. The amplifier is described in terms of application and performance capabilities. Operating instructions, functional purposes of major circuits of interest to the operator, and preventive maintenance and repair are set forth. Unpacking and packing for shipment or storage, initial installation, and warranty information are included.

1.1.3 Use of This Manual

This manual is limited to the standard amplifier and the most common options. Amplifiers ordered with special options will have addenda pages included with the basic manual, containing material applicable for their special operation and maintenance.

1.2 SPECIFICATIONS AND STANDARD AMPLIFIER OPTIONS

Table 1.2-1 gives the performance characteristics of the standard amplifier. Table 1.2-2 sets forth the modifications available as options to the standard amplifier.

1.3 PHYSICAL DESCRIPTION

Each amplifier consists of a PPM-focused metal-ceramic traveling-wave tube, a regulated solid-state switching power supply, and an integral air-cooling system assembled within a 3 1/2-inch enclosure. The amplifier may be mounted in a standard 19-inch rack. Figure 1.3-1 (installation control drawing) shows the outline and mounting dimensions of the standard amplifier with identification of front- and rear-panel features. The amplifier is modularly assembled to facilitate maintenance and replacement. Figure 1.3-2 (interconnect diagram) is an electrical wiring diagram showing interconnections of the major components. Table 1.3-1 lists the operating modules of the amplifier. Critical drawings, such as schematics, assembly drawings, and parts lists for the overall unit, as well as the individual modules, are included in Sections 7.0, 8.0, and 9.0 of this manual.

TABLE 1.2-1
SPECIFICATIONS

TWTA Power Output (Watts/Min.)	Frequency (GHz)	Gain At Rated Power (dB/Min.)	TWTA Model Number	RF Connector Type Input/Output	TWT Model Number
1.0 to 18.0 GHz Models					
10	Standard Bands				
	1.0 to 2.0	30	8010H09*000	N	417HD
	2.0 to 4.0	30	8010H01*000	N	564H
	4.0 to 8.0	30	8010H02*000	N	648HD
	8.0 to 12.4	30	8010H03*000	N	771HD
	12.4 to 18.0	30	8010H04*000	N	848HD
	Multibands				
	2.0 to 8.0	30	8010H19*000	N	8582H
	3.0 to 8.0	30	8010H13*000	N	646H
	3.9 to 11.7	30	8010H16*000	N	664H
	4.0 to 10.5	30	8010H06*000	N	648HDS
	6.5 to 13.5	30	8010H07*000	N	771HDS
	7.0 to 16.3	30	8010H17*000	N	785HD
	8.0 to 18.0	30	8010H15*000	N	846H
20	Standard Bands				
	1.0 to 2.0	30	8020H09*000	N	418H
	2.0 to 4.0	30	8020H01*000	N	568H
	4.0 to 8.0	35	8020H02*000	N	640H
	8.0 to 12.4	35	8020H03*000	N	783H
	12.4 to 18.0	35	8020H04*000	N/UG419	856H
	Multibands				
	1.4 to 2.4	30	8020H10*000	N	419H
	8.0 to 18.0	30	8020H15*000	N	889H
30	4.0 to 8.0	30	8030H02*000	N	670HB
	8.0 to 12.4	30	8030H03*000	N	18707H
18.0 to 40.0 GHz Models					
1	18.0 to 26.5	30	8001H11*000	UG596 (WR42)	911H
	26.5 to 40.0	30	8001H12*000	UG600 (WR28)	912H
10	18.0 to 26.5	40	8010H11*000	UG596 (WR42)	991H
	26.5 to 40.0	40	8010H12*000	UG600 (WR28)	992H

*F or R denotes location of RF ports

TABLE 1.2-1 (CONTINUED)

Electrical

Gain at Rated Power Output		See Table
Duty		CW
Input Voltage		99 to 132 Vac
Input Frequency		47 to 63 Hz
Power Consumption	8001H	115 Watts ²
	8010H	250 Watts
	8020H	280 Watts
Noise Figure		35 dB maximum
Spurious Modulation (at saturation)		-50 dBc
Coax Input/Output Impedance		50 nominal
Gain Stability		0.25 dB/24 Hours ³
Load VSWR (no damage)		2.5:1 maximum ⁴

Mechanical

Size/Configuration	(See Figure 1.3-1)
Weight	20 pounds (9.1 kg)

Environmental

Operating Temperature	0 to 50°C ambient
Altitude	10,000 feet maximum

1. Power and gain slightly lower at band edges.
2. This indicates maximum power consumption of any model in that series. For information on a specific model, consult factory.
3. At constant drive and temperature after warmup period.
4. Option J is required for higher load VSWR applications.

TABLE 1.2-2
STANDARD OPTIONS

Option A - 220/240 V Input Voltage

Provisions for 198 to 264 VAC at 50/60 Hz Operation.

Option E - Rackmounting

Rack-mount ears for standard EIA 19-inch cabinets.

Option F - Local/Remote

Provides remote control of the amplifier's ON/OFF prime power switch and the OPERATE/STANDBY switch. Fault status and an analog voltage, proportional to the amplifier's helix current, are also made available. This option requires user to supply 15 VDC at 300 mA for remotely operating the unit.

Option H - TTL Remote Interface

This option replaces the standard Option F with TTL level interfaces.

Option J - Output Isolator

Protects the traveling-wave tube from high external-load VSWR conditions. Isolators are rated for full reflected power.

Option K - High Gain

Adds a solid-state amplifier at the input to the traveling-wave tube for higher gain when only minimal drive power is available. Consult the factory for specific requirement.

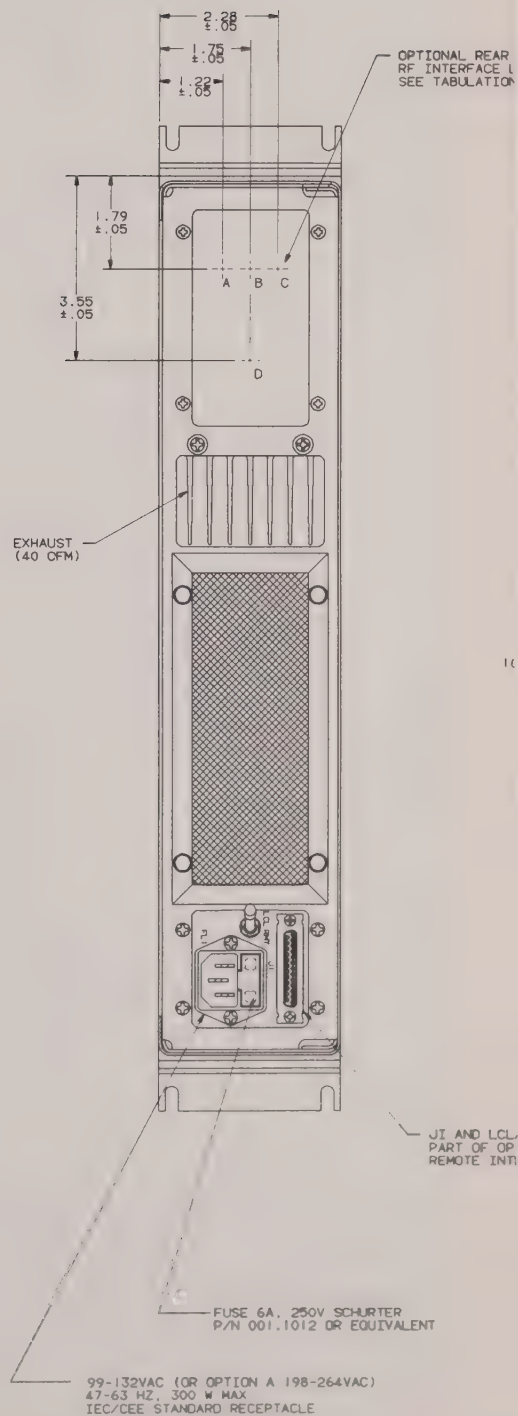
Option N - Variable Attenuator

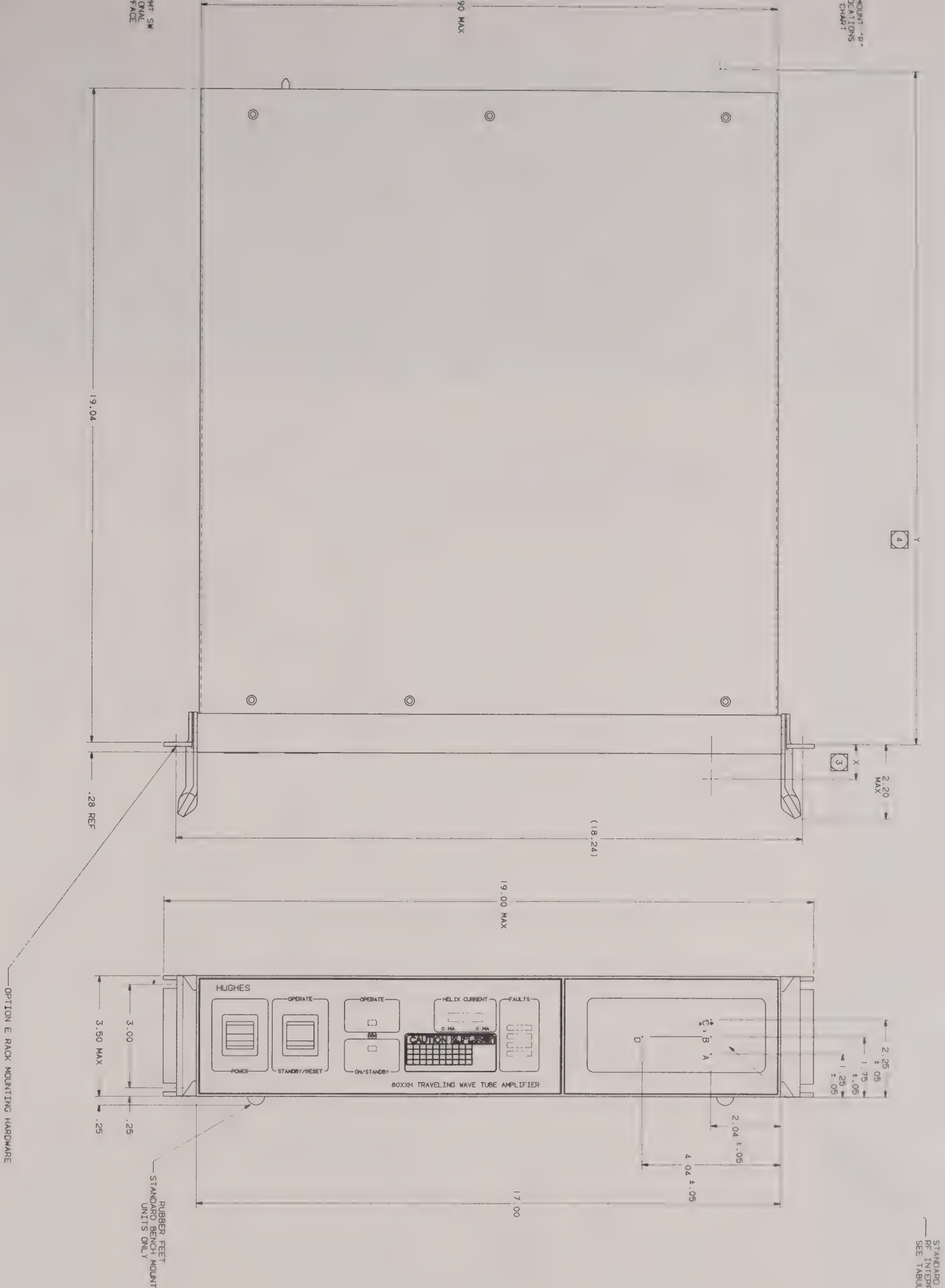
A variable front-panel RF attenuator provides gain control over more than a 20-dB range.

Option P - IEEE Std. 488-1978 Interface

Allows digital control of the amplifier through an industry-standard parallel interface bus. Useful in automated stations. All command and status indicators are bus addressable. Instruction set is CII/Mate compatible.

RF INTERFACE				
UNIT DESIG.	INPUT		OUTPUT	
	LOCATION	TYPE	LOCATION	TYPE
8001H11	C	WR42, UG596	A	WR42, UG596
8001H12	C	WR28, UG600	A	WR28, UG600
8010H01	D	N	B	N
8010H02	D	N	B	N
8010H03	D	N	B	N
8010H04	D	N	B	N
8010H06	D	N	B	N
8010H07	D	N	B	N
~~8010H08~~	~~D~~	~~N~~	~~B~~	~~N~~
8010H09	D	N	B	N
8010H11	C	WR42, UG596	A	WR42, UG596
8010H12	C	WR28, UG600	A	WR28, UG600
8010H13	D	N	B	N
~~8010H14~~	~~D~~	~~N~~	~~B~~	~~N~~
8010H15	D	N	B	N
8010H16	D	N	B	N
8010H17	D	N	B	N
8010H19	D	N	B	N
8020H01	D	N	B	N
8020H02	D	N	B	N
8020H03	D	N	B	N
8020H04	D	N	B	WR62, UG419
~~8020H06~~	~~D~~	~~N~~	~~B~~	~~N~~
8020H09	D	N	B	N
8020H10	D	N	B	N
8020H15	D	N	B	N
8030H03	D	N	B	N

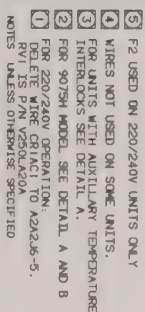




J1 REMOTE CONTROL INTERFACE (OPTION F)		
CANNON DBMA-25S OR EQUIVALENT		
PIN #	NOMENCLATURE	CHARACTERISTICS
COMMANDS		
1	POWER ON	FORM "A" CONTACT TO GROUND 150 MA MAX
2	OPERATE	FORM "A" CONTACT TO GROUND 65 MA MAX
13	COMMAND ENABLE +5VDC	15V ±.5V @ 215 MA MAX USER SUPPLIED
25	BEAM OFF (W/RCU SUBSYSTEM USE)	FORM "A" CONTACT TO GROUND 65 MA MAX
STATUS		
3	POWER ON	OPEN COLLECTOR DARLINGTON OUTPUT (EMITTER GROUND) +15V MAX STANDOFF
5	OPERATE	GROUND
22	REMOTE INDICATOR	FORM "A" CONTACT TO GROUND 150 MA MAX
FAULTS		
6	LINE UNDER VOLTAGE	OPEN COLLECTOR DARLINGTON OUTPUT (EMITTER GROUND) +15V MAX STANDOFF
7	INTERLOCK	GROUND
8	THERMAL	GROUND
9	HELIX CURRENT	GROUND
4	SUMMARY FAULT	LOW-FAULT (V) Z OUT=1KΩ, HIGH-FAULT (V) Z OUT=1KΩ, HIGH-FAULT (V) Z OUT=1KΩ
14	SUMMARY FAULT	LOW-FAULT (V) Z OUT=1KΩ, HIGH-FAULT (V) Z OUT=1KΩ
15	LOW RF (RCU OPTION)	Z OUT=1KΩ
ANALOG		
10	HELIX CURRENT	0 TO 5V FULL SCALE, Z OUT=1KΩ
11	RF PWR (RCU OPTION)	SAME
17	GROUND	CHASSIS

J1 TTL REMOTE CONTROL INTERFACE (OPTION H)		
CANNON DBMA-25S OR EQUIVALENT		
PIN #	NOMENCLATURE	CHARACTERISTICS
COMMANDS		
1	POWER ON	1 TTL LOAD, 1.5V INPUT, LOW-TRIE
2	OPERATE	1 TTL LOAD, LOW-TRIE
25	RESET	1 TTL LOAD, LOW-TRIE
STATUS		
3	POWER ON	OPEN COLLECTOR DARLINGTON OUTPUT, (EMITTER GROUND) +15V MAX STANDOFF
5	OPERATE	GROUND
14	FAULT	GROUND
20	READY	GROUND
16	POWER ON	GROUND
19	READY	GROUND
23	OPERATE	TTL OUTPUT, FANOUT =2
24	FAULT	GROUND
17	GROUND	CHASSIS

Figure 1.3-1 Installation control drawing.

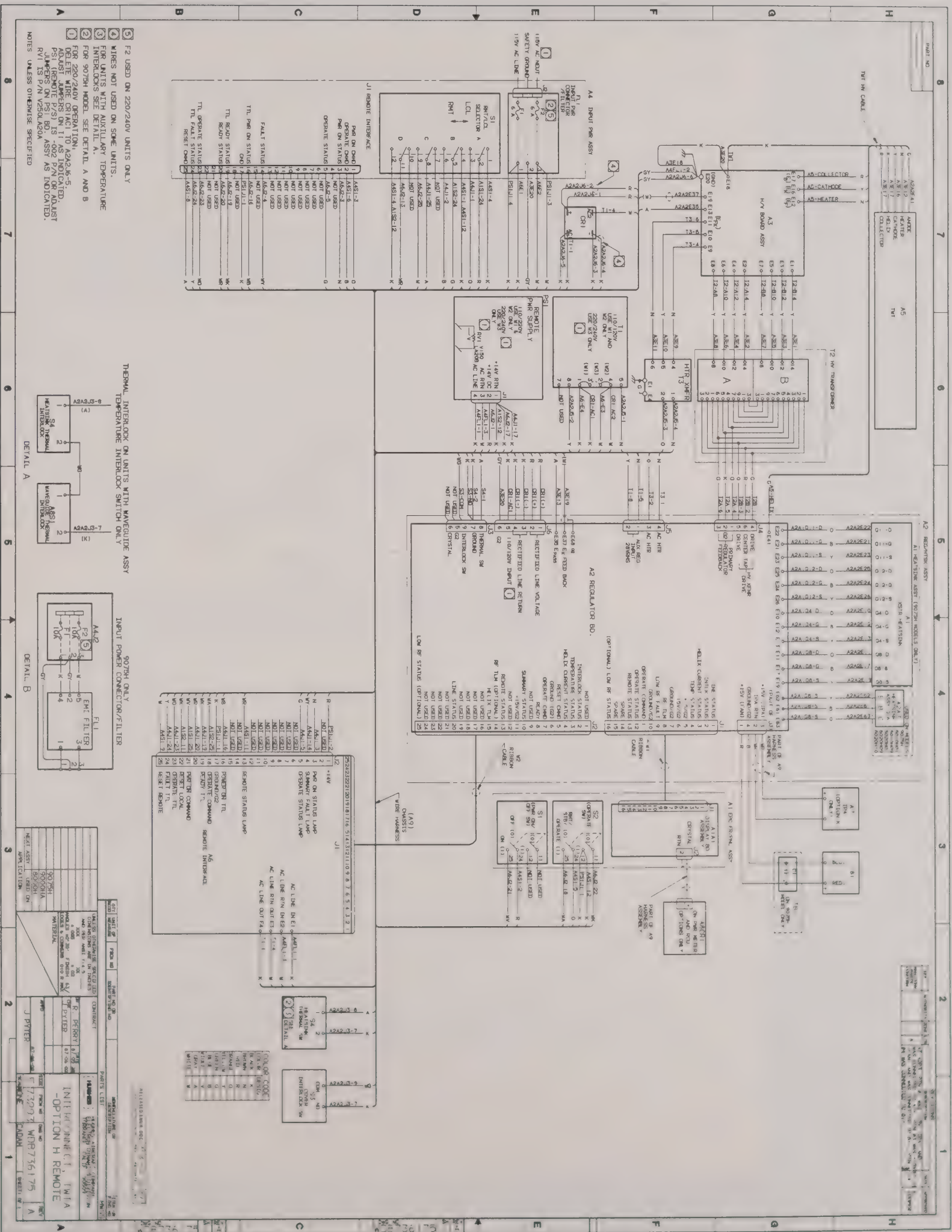


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TABLE 1.3-1
BASIC MODULES, INSTRUMENTATION AMPLIFIER

Display Board	B737507
Regulator Board ¹	B750466
High-Voltage Board ¹	B747180
Remote Interface Board (Option F)	B724485
TTL Remote Interface Board (Option H)	B736158

¹These printed wiring boards contain model-dependent components. When ordering spares or replacements, please specify the TWTA model number for compatibility.



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Figure 1.3-4 Interconnect, TWTA - option H remote.

2.0 OPERATION

2.1 INTRODUCTION

The 8000HA series amplifiers are reliable, high-performance instruments designed for easy and trouble-free operation. It is important to read Sections 2.2 and 2.3, which provide general information about the amplifier, before operating the amplifier. Descriptions of the controls and indicators and operation and shutdown instructions follow in Sections 2.4 and 2.5.

2.2 WARNINGS

The following are general precautions to be taken in operating the amplifier.

WARNING

Lethal voltages exist in the operation of the amplifier. Remove all power connections before performing any work within the amplifier enclosure.

WARNING

The traveling-wave tube inside the amplifier contains beryllium oxide ceramics. Do not attempt to disassemble the TWT. Proper disposal of damaged or worn-out TWTs is required.

2.3 OPERATING REQUIREMENTS AND CAPABILITIES

2.3.1 Amplifier System Requirements

As a laboratory instrument, the amplifier is designed to function with a variety of systems. The broad-bandwidth characteristic of the TWT is the key parameter providing this capability. The TWT is a rugged device, but requires care in several areas. Primary concerns in the setup and operation of the amplifier are preventing high VSWR at the amplifier output and avoiding overdriving the input of the amplifier.

CAUTION

Use RF system components that can safely handle the output power of the amplifier.

2.3.2 System RF Output Power Requirements

The amplifiers are rated at a minimum RF output of 1, 10, 20, and 30 watts, depending on the model. They may, however, provide 3 to 4 dB of RF power output above their ratings.

Therefore, the components of the RF output system should be capable of handling this power with a margin of safety.

CAUTION

Never operate the amplifier into a load VSWR greater than 2.5:1 unless an appropriately rated isolator has been installed.

2.3.3 Amplifier Load VSWR Requirements

A mismatch greater than 2.5:1 VSWR at the RF output of the traveling-wave tube (TWT) may cause permanent damage to the TWT. A TWT damaged because of such mismatching may not remain adjustable under the warranty provisions. For systems having a potentially high VSWR or requiring minimum degradation of output because of interaction between system and TWT, Option J (output isolator) should be specified for TWTA self-protection or performance improvement.

2.3.3.1 Match System Bandwidth to Amplifier Bandwidth - When operating the amplifier into waveguide systems, take care that the cutoff frequency of the waveguide system does not occur within the passband of the TWTA. This mid-frequency range cutoff point may be seen by the amplifier as a VSWR higher than 2.5:1, resulting in amplifier instability or even permanent damage to the amplifier.

2.3.3.2 Avoid Amplifier RF Load Short Circuits - Never operate the amplifier into a system open or short circuit. This may result in a VSWR higher than 2.5:1 at the amplifier output. Take care that all system connections are fully connected and snug before operating the amplifier. If it is necessary to disconnect the RF lines during operation of the amplifier, always pre-install an isolator to protect the TWT. The RF lines should only be disconnected when the unit is in the standby or off condition.

2.3.3.3 Properly Terminate TWTA RF Input - Although the RF input is not as susceptible as the RF output to damage caused by VSWR mismatch, it is good practice to properly terminate with a load not exceeding 2.5:1 VSWR. The unit can be induced to oscillate if operated with the input not properly terminated, which could cause a TWT failure. Overdrive by 3 dB can damage the input circuit of the TWT.

CAUTION

Never drive the TWT beyond saturation. (See Figure 2.7-1.) Maximum drive level versus frequency is indicated on unit front panel drive label.

2.3.4 Amplifier Output-Power Capabilities

Some amplifier models have gain up to, or greater than, 50 dB in areas within their bandwidth. Take care that the amplifier is not driven beyond the saturation point.

2.3.4.1 General Procedures to Avoid Oversaturation - Avoid oversaturation by observing the following precautions:

1. Check the frequency of operation and note the output power expected.
2. Start with a very low level of RF drive and monitor the output power (-20 dBm starting point).
3. Increase drive in even steps, while observing output power.

NOTE

Output power should always increase with increasing input power until saturation is reached.

4. If output power begins to decrease with increased drive, immediately reduce the drive.

2.4 AMPLIFIER OPERATION

CAUTION

Study the preceding sections before operating your amplifier.

2.4.1 Controls and Indicators

Figure 1.3-1 shows the front and rear views of the amplifier and calls out the controls, indicators, and connectors. Table 2.4-1 describes the functions of the controls. Table 2.4-2 describes the fault indicators.

**TABLE 2.4-1
TWTa CONTROLS**

Nomenclature	Function
POWER	Connects prime power to all EPC circuits and initiates filament warm-up cycle for TWT.
OPERATE STANDBY/RESET	OPERATE turns on High-Voltage section of EPC and sequences TWT to active state. STANDBY/RESET de-energizes HV circuits and also resets the fault counter.

TABLE 2.4-1 (CONTINUED)

Nomenclature	Function
Remote/LCL (On rear panel)	Transfers the two preceding control functions exclusively to a remote location. This option also provides fault indication and an analog voltage proportional to helix current at the remote location, regardless of switch position.

**TABLE 2.4-2
FAULT INDICATORS**

Nomenclature	Condition
HELIX	Helix current of the TWT has exceeded the factory-set SAFE level, and protective shutdown has occurred.
INTLK	The mechanical interlock switch has been opened.
TEMP	The thermostat switch located near the output end of the TWT has sensed a baseplate temperature exceeding 185°F (85°C).
LINE	The ac prime power applied to the TWTA is insufficient to maintain the precise regulated voltages. This occurs when the ac input voltage is less than 90 percent of nominal rated voltage.

2.4.2 Initial Operation

2.4.2.1 Installation - If this is the first installation or a reinstallation after repair, refer to Paragraph 6.3 for instructions on mechanical and electrical installation and checkout.

2.4.2.2 Primary Power Requirement - Confirm that the primary power source is of the same type that is specified on the amplifier's front panel.

2.4.2.3 Connecting to Primary Power - Observe that the front panel POWER rocker switch is off (lower part of rocker switch level with panel). Connect the amplifier line cord to a primary power source that is of the same type as specified on the amplifier's front panel label.

2.4.3 System Setup

1. Check that the front panel POWER rocker switch is off.
2. Connect the amplifier into the system or setup with the RF source to the RF INPUT connector and a suitable RF load connected to the RF OUTPUT connector.
3. Check that the RF load is capable of dissipating the TWT output power at the intended operating frequency.
4. Check that the exhaust air flow is not blocked. A 3-inch minimum clearance is recommended from the exhaust port to any obstruction.

2.4.4 Power On

On the front panel, switch the POWER rocker switch on. The green ON/STANDBY display LED will light. If the LED does not light, check the fuses and the line cord. The fan should be running. A 3- to 6-minute delay for the TWT heater to warm up is initiated.

2.4.5 Traveling-Wave Tube Amplifier On

1. Check to ensure that the RF drive source is off or, if that is not possible, at a suitably low level of power output.
2. On the front panel, switch the OPERATE rocker switch on. If the amplifier has completed warm-up, the green OPERATE display LED will light.
3. Check to see that there is a current indication on the front-panel 10-segment HELIX CURRENT bar graph display. No other display LED should light.

NOTE

1. Some TWTs have very low helix current with no RF drive. Thus, the helix current display may not indicate until RF drive is applied.
2. Actuation of the OPERATE switch before complete warm-up will not damage the TWTA. The automatic circuits will sequence to OPERATE after latch-in of the internal timer.

2.4.6 Applying RF Source

1. Apply RF drive at a level 10 to 20 dB below the labeled drive for the frequency of interest.
2. Monitor the RF output by means of a directional coupler and power meter (see Paragraph 4.3).

3. Slowly increase RF drive-source power until the RF output power is at its peak. This is the saturation level of the TWT (see discussion in Paragraph 2.7.1) and will vary over the operating band.
4. If possible, monitor the input power. Check the test data sheets provided or the front panel drive label to ensure that the unit is not overdriven.

2.4.7 Routine Operation

2.4.7.1 Removing RF Output - During operation, broadband noise is always present in the output of the amplifier. To make measurements or tests that are difficult or impossible in the presence of this noise, set the OPERATE/STANDBY/RESET switch to STANDBY/RESET. The OPERATE light will go out. The TWTA is now in the STANDBY mode.

If making a change that involves open or short circuiting of the load port, always set the TWTA to the STANDBY mode.

NOTE

Operation of the TWTA in the STANDBY mode for periods exceeding eight hours may reduce ultimate TWT life. It is recommended that the unit be completely powered down and restarted when needed.

Unattended protection is provided for applications in which the unit is operated in an unattended location. If the helix fault counter senses two faults, the logic is powered down and requires a manual or remote reset.

2.4.7.2 Helix Fault Reset - Should the amplifier be overdriven by the RF source, the helix-protect circuitry will switch the unit to the STANDBY mode. The OPERATE light will go out, and the HELIX fault light will light. Reduce the RF source power level and switch the OPERATE/STANDBY/RESET switch to STANDBY and then back to OPERATE. The TWTA will return to the OPERATE mode in about 10 seconds.

2.4.8 Turn Off

To turn the unit off, remove the RF drive, switch the amplifier to the STANDBY mode, and switch the POWER switch to the OFF position.

2.4.9 Remote Operation

On standard amplifiers without the remote option, remote ON and OFF operation can be achieved as follows:

1. Connect the amplifier as in Paragraphs 2.4.1 and 2.4.2.
2. Switch the amplifier to OPERATE and establish the RF drive and output levels as in Paragraphs 2.4.2 through 2.4.4.
3. The amplifier can now be turned on and off remotely by switching the primary power on and off. With primary power applied through the line cord, the

amplifier will automatically time through its warm-up period and sequence to the OPERATE mode.

4. Should an RF overdrive condition cause the amplifier to go to the Heater Shutdown mode, removal and reapplication of the primary power will reset the unit. It will return to the OPERATE mode following the automatic warm-up sequence.

2.5 EMERGENCY PROCEDURE

Immediately set the POWER rocker switch to the OFF position for emergency power shut-down.

2.6 REMOTE CONTROL

The optional remote-control capability can be used to monitor and control the amplifier from a remote location. Option F provides relay interface for control, Option H provides TTL logic interface for remote control, and Option P provides a digital IEEE 488-interface bus for remote control.

Switching between local and remote modes of operation can only be done at the amplifier's rear panel. When the REMOTE switch is set to the remote position, the turn-on sequence is controllable only from the remote location. Status and Fault indicators are always present, buffered through the remote interface board.

2.7 TRAVELING-WAVE TUBE AMPLIFIER CHARACTERISTICS

Traveling-wave tube amplifier characteristics that directly affect your operation of the amplifier are described in this section. For more general information about the way TWTAs work, see Section 3.2.1.

Characteristics important to operation are: RF input versus RF output, noise performance, RF duty cycle, RF modulation, and gain variations.

2.7.1 RF Input Versus Amplified RF Output

A plot of the amplified RF output power versus the RF input driving the amplifier is called a "compression" or "gain transfer" curve. An example of a compression curve is shown in Figure 2.7-1.

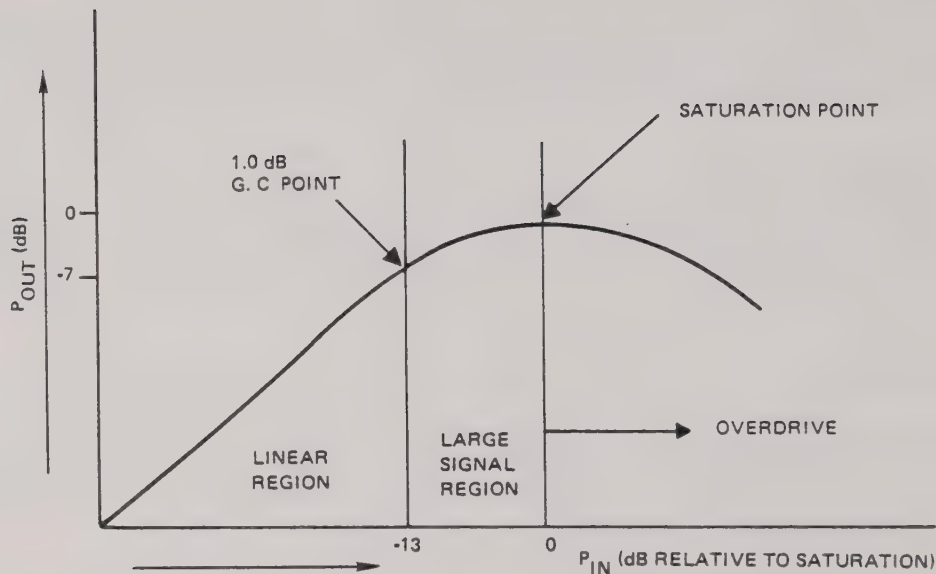


Figure 2.7-1 Sample "gain transfer" or "compression curve".

Note that the compression curve is linear at lower power input values, and a change in RF input drive causes an equal increase in power output. This linear region is where maximum gain is achieved. It is called the "small signal gain" region.

Beyond this region, further increases in input drive result in smaller and smaller increases in output. Finally, a point is reached when further increases in drive cause no increase in output. This is the "saturation point" of the compression curve. Note that the saturation area is rather broad, and small changes in input power result in almost no change in output power.

As the RF drive is further increased, the power output will begin to decrease. This is called the "overdrive" region. Continued operation in this region may damage the TWT.

2.7.2 Noise Performance

Thermal noise is present at the input of the amplifier. This is increased at the output by the characteristic noise figure, bandwidth, and gain of the amplifier. In operation, the resulting noise power output of a TWT amplifier can be as high as -30 dBm/MHz.

In addition, AM and PM (or FM) residual modulation sidebands are generated by ripple voltage on the cathode or beam power supply. These consist of fundamentals and harmonics of the power line and 15 kHz converter switching frequencies. This noise is typically 50 dB below the carrier (-50 dBc).

2.7.3 RF Duty Cycle

The TWT used in the Hughes amplifier is nongridded and operates continuous wave. The RF duty cycle can be varied from zero to 100 percent duty by pulsing the RF drive. The maximum peak pulsed power will equal the saturated continuous wave power. The TWT acts as a delay line of typically 5 to 10 nanoseconds. Pulse fidelity is maintained on pulses as short as 25 nanoseconds.

2.7.4 RF Modulation

With FM and PM, operate the amplifier at saturation to attain the maximum RF output at low distortion. With AM, operate the amplifier in the linear region for lowest distortion.

2.7.5 Intermodulation Distortion

As broadband devices, TWTAs can be used to amplify more than one carrier at a time because of their instantaneous bandwidth characteristic.

When amplifying multiple carriers, intermodulation (IM) products will occur with levels dependent on the region of operation. Because their frequency placement comes closest to the desired carriers, third order products are of greatest concern. Figure 2.7-2 shows a typical third-order IM product curve. Note that, in the linear gain region, a change of 1 dB in RF output causes a 3-dB change in the third-order IM product level. In addition, note that the RF output power is distributed among the carriers and their IM products. Therefore, if the saturated output power for a single carrier is 20 watts, and the TWT is driven to saturation by two carriers, the output of each amplified carrier will be somewhat less than 10 watts because of the power absorbed in generation of the IM products. The intercept point is typically 5 dB greater than the rated single carrier power output.

2.7.6 Harmonics

The second harmonic content will be maximum when the TWT is operated at the saturated level and is typically 8 to 12 dB below the fundamental frequency output. In some cases, when the bandwidth is an octave (that is, the upper edge of the band is twice the frequency of the lower edge), the level of the second harmonic may be higher.

2.7.7 AM/PM Conversion

Amplitude variations in RF input will generate low-level phase modulation sidebands on the carrier. This is called AM to PM conversion. The largest coefficient occurs approximately 5 dB below the saturation drive level and is typically 6°/dB or less. The total phase shift from no drive to saturation drive is nominally 50°.

2.7.8 Gain Variations

Because the TWT's gain varies across its frequency range, the gain transfer curve shown in Figure 2.7-1 shifts accordingly. As a result, it is necessary to use different drive levels to achieve maximum RF output at different frequencies. Check the test data provided with each unit to determine the gain at rated power.

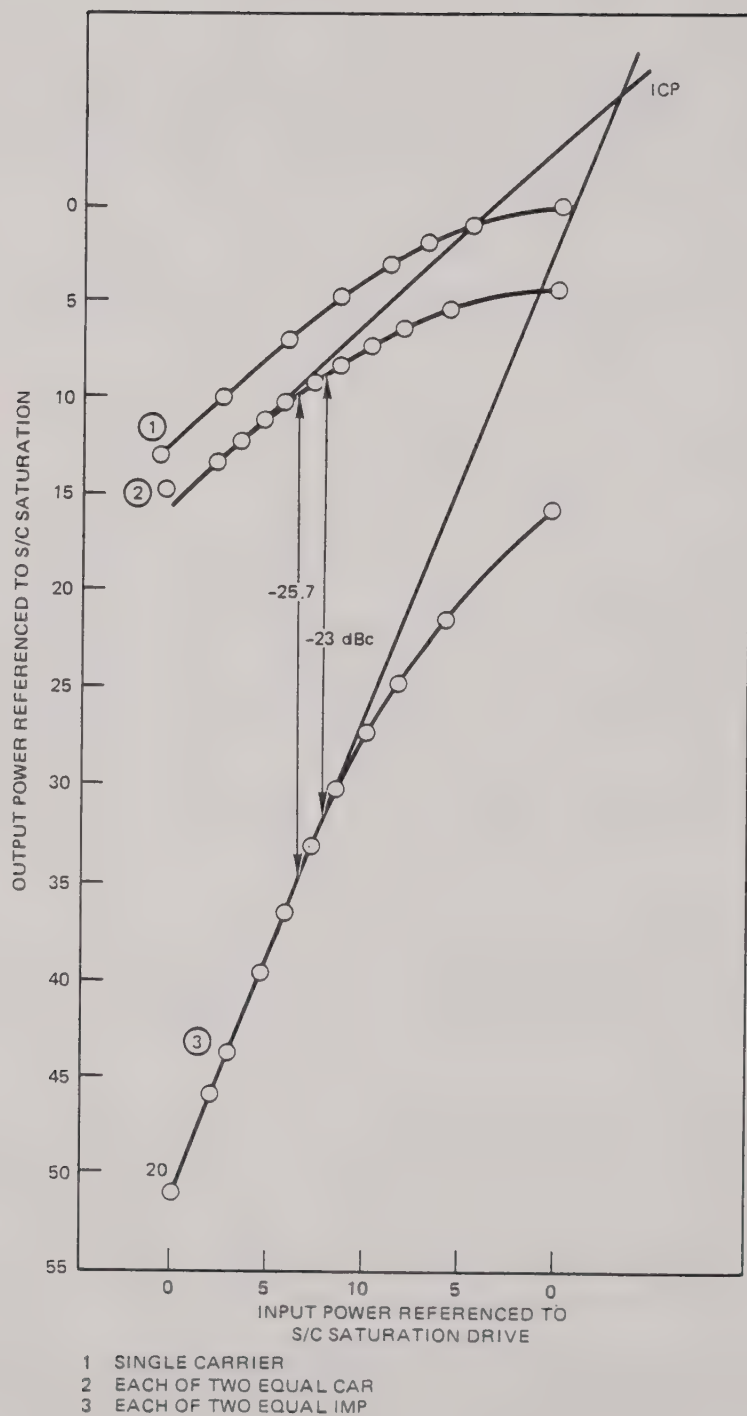


Figure 2.7-2 Typical third-order product curve.

When the amplifier is used with a constant drive sweeping source, adjust the drive level at the frequency of maximum gain. This procedure alleviates overdrive problems when the RF source is swept across the band. In applications in which gain variations cannot be tolerated, use other techniques. One technique is to apply a feedback signal from the RF output back to a gain control circuit at the RF source to reduce the variations in output. Another is to use a gain equalizer between the RF source and the amplifier. A gain equalizer option is available from the factory where only limited dynamic range leveling loops or pulsed RF operation prevents proper leveling.

3.0 FUNCTIONAL THEORY OF OPERATION

This section presents an overall functional description of the operation of the modules of the 8000H Instrumentation Amplifier. It is meant to provide you with a theory of operation that describes how the circuits perform their functions.

3.1 AMPLIFIER FUNCTIONAL BLOCK DIAGRAM

Figure 3.1-1 is the detailed block diagram of the amplifier. The amplifier can be functionally separated into six circuits. These are:

- The logic circuits: Control automatic start-up, fault display, timing, fault sensing, and the front panel inputs.
- Auxiliary regulator: Supplies ± 15 volts to the helix regulator; ± 15 volts to the logic circuits, primary regulator, fan, and the optional intermediate power amplifier (IPA); base drive to the high voltage switches; 50 to 400 V to the anode regulator; drive to the heater transformer; and synchronization to the primary regulator.
- Primary regulator: Supplies primary power to the high-voltage circuits; provides high-voltage regulation and controlled high-voltage charge-up.
- Helix regulator: Accurately sets and regulates the TWT cathode voltage, detects high-voltage faults (displayed as a Helix Fault), and generates helix current metering.
- TWT: Provides the RF amplification of the drive source.
- Remote circuit: Remotes all front-panel functions and indicators.

The detailed blocks shown in Figure 3.1-1 are provided to clarify the detailed parts of the main circuits described above. The description of each circuit is included in the paragraph indicated.

The four printed circuit boards and the chassis wiring provide the electronic functions discussed in Section 3.1. The electronic wiring is shown on the interconnect diagram WDB 732425 (basic TWTA without remote control option).

3.2 INPUT POWER

The input power passes through the rear-panel-mounted line connector on the line filter FL1 (A4). The power is then wired to the on/off switch (A1S1) located on the front panel and to the auxiliary step-down transformer (T1). This transformer serves as the splitting point between the auxiliary regulator and primary regulator circuit, as shown in Figure 3.2-1. The primary of T1 is wired either in series for 220-Vac input or parallel for 110-Vac input to produce the 28-V rms input to the auxiliary regulator. The line is also rectified to provide the 340 Vdc required for the primary regulator.

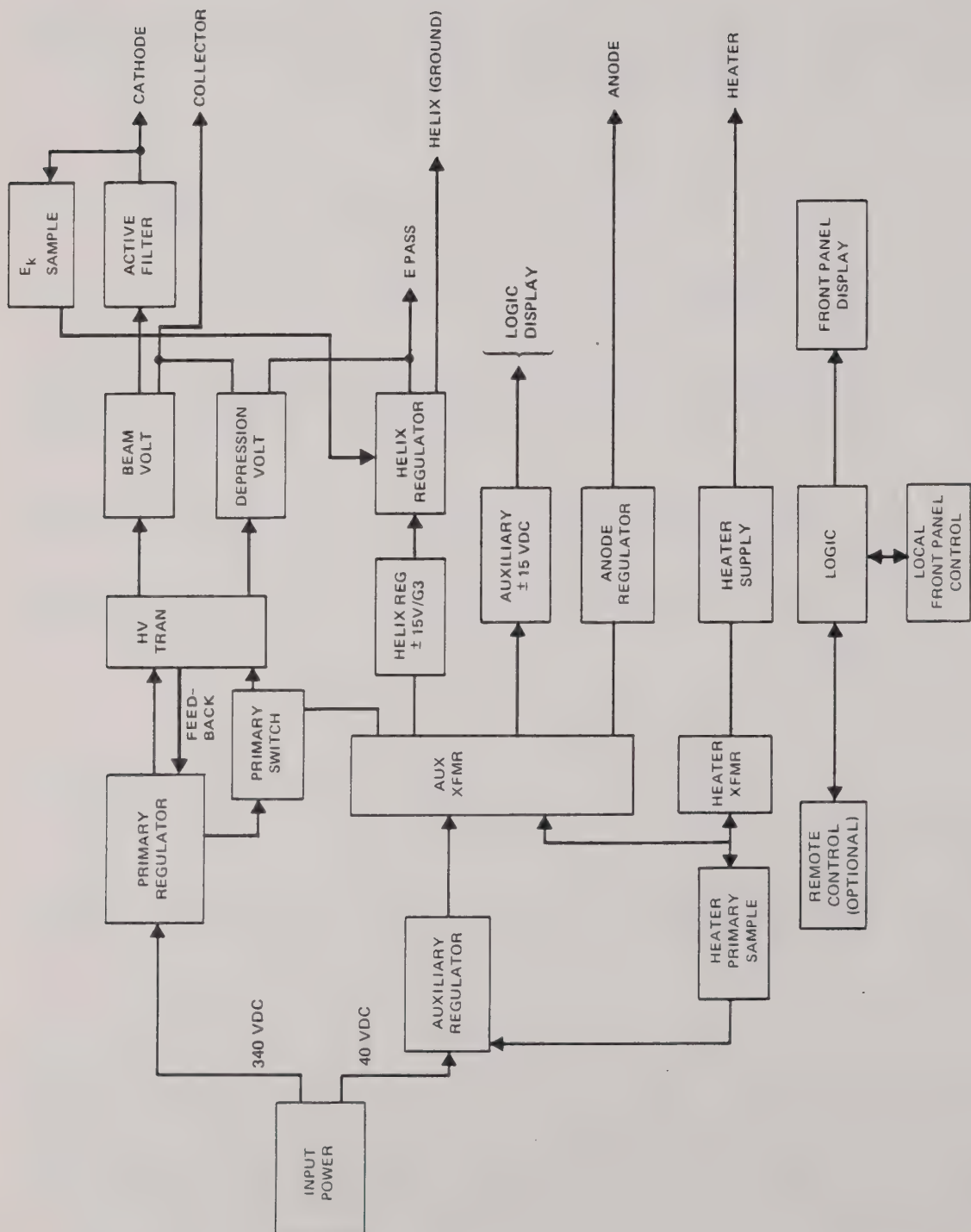


Figure 3.1-1 EPC block diagram.

The secondaries of A2T3 supply the correct voltage ratio and voltage isolation for each separate auxiliary power circuit. Terminals 4, 5, and 6 provide ± 15 -Vdc bias voltage to U8 of the helix regulator. This voltage is referenced to G3 (helix meter voltage), which is connected to G2 (chassis ground) through either R84, R85, or R38, depending upon the helix current level specified for that TWT.

Terminals 7, 8, and 9 provide the ± 15 VDC for the Logic. The voltage level will vary from 13 to 17 volts, depending upon the exact heater voltage adjustment, and is in reference to G2 (chassis).

Terminals 13, 14, and 15 provide the base drive for the primary regulator switching transistors, Q11 and Q12.

Terminals 16 and 17 provide the ac power, which is rectified and filtered for the anode supply voltage to the TWT. The voltage is then processed by the regulator circuit, which consists of Q13 and Q14. The voltage is set using potentiometer R71, and can be set from 50 to 400 VDC.

The unattended operation circuit is shown as part of Figure 3.2-1. After the fault counter is tripped (factory set at two faults), U5-1 output goes low, which energizes K1 through optical isolator U11. When relay K1 is energized, U2-10 goes high, and the auxiliary regulator is inhibited. This removes power from the heater circuit to avoid damage to the TWT due to extended operation in standby. All auxiliary power is now inhibited until prime power is removed and reapplied by cycling the power-on switch.

3.4 PRIMARY REGULATOR

The primary regulator is a pulse-width modulated (PWM) downregulator that converts the 340-VDC bus from the rectified ac line to a 100-VDC (nominal) voltage at the primary of the high-voltage transformer. A schematic for the primary regulator is shown in Figure 3.4-1. Its purpose is to generate the cathode and collector voltages while filtering out the line ripple components.

Although the primary regulator adjustment potentiometer, R62, is used to adjust the "E-PASS" voltage (E35), this adjustment must be done in series with the helix regulator adjustment, R100. First, adjust R100 completely CCW, then adjust R62 until the cathode voltage is 150 VDC less than the desired cathode voltage. Next, adjust the helix regulator to provide the exact cathode voltage for the specific TWT. Readjust R62 for 150 VDC on "E-PASS." The feedback signal from the high-voltage transformer is rectified and sampled by operational amplifier U6, which acts as an error amplifier. The output of U6 drives the PWM-chip input U3 Pin 9 proportionally to the high-voltage transformer's output voltage. The outputs of U3 at Pins 11 and 14 alternately pulse Q5 and Q6 to provide the PWM rectangular-wave drive to Q4 and Q8, which chop the 340 VDC. This chopped voltage is next filtered by L2 and CR54 to provide the desired voltage (100 VDC nominal) to the center tap of the high-voltage transformer (T2) primary.

Transistor Q2 and its associated circuitry provide the signal that keeps the primary regulator synchronous with the auxiliary regulator.

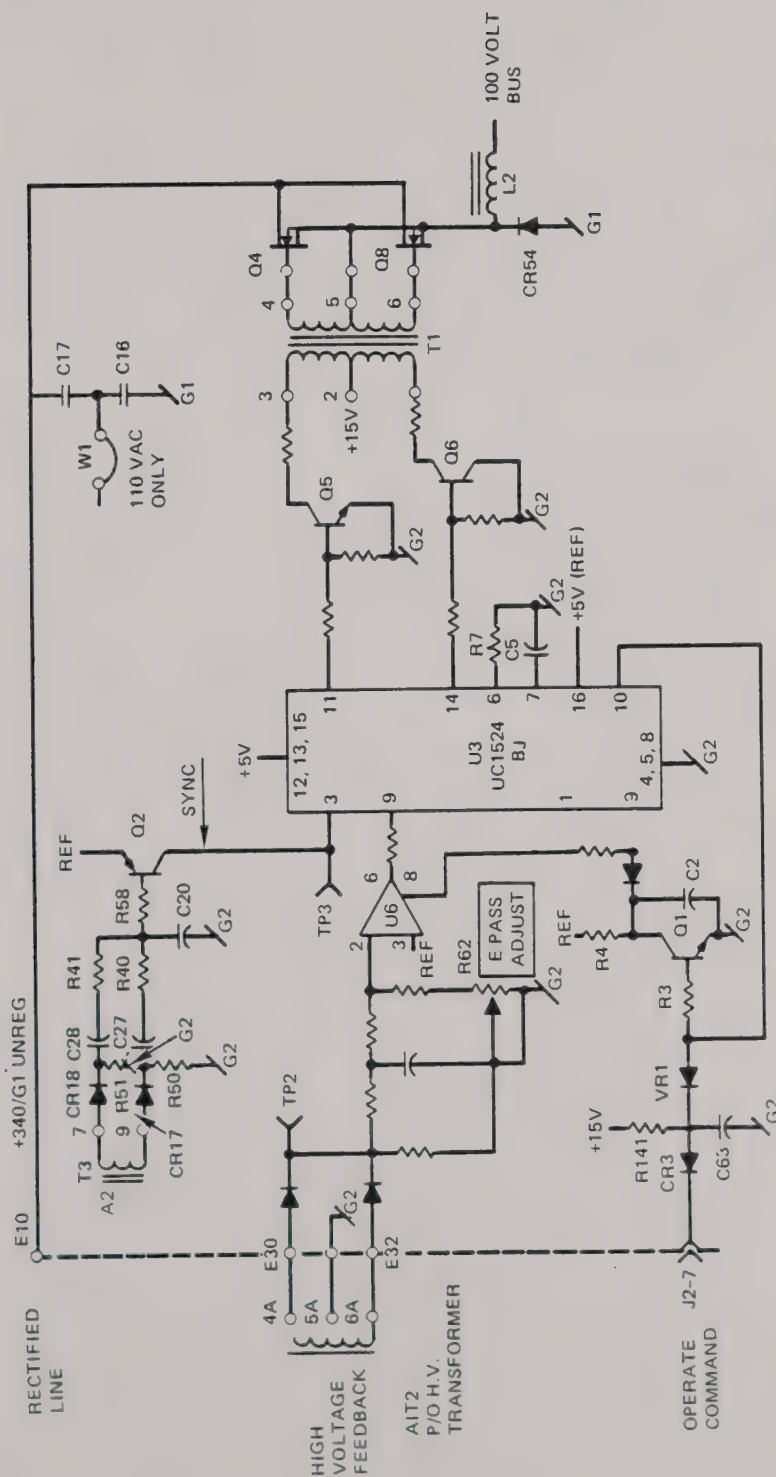


Figure 3.4-1 Primary regulator.

The soft start of the primary regulator is accomplished with R4 and C2 ramping up to enable Pin 8 of U6 when the unit is in the OPERATE mode. Without an operate command, Q1 is turned on through J1-12, inhibiting the PWM chip (U3).

Square-wave drive to the high-voltage transformer, T2, is derived from the auxiliary transformer Pins 13, 14, and 15 as drive to Q11 and Q12, which, in turn, drive T2.

Current transformer, A2T2, monitors each pulse of the high-voltage converter for any indication of overcurrent. U1-C compares the current pulse magnitude to a fixed reference and triggers a U3 inhibit if overcurrent is detected. This circuit protects the power FETs from abnormal loads or high-voltage arcs.

The logic indication of the converter overcurrent circuit is summed into the helix fault gates and routed through the counter/latch U7.

3.5 HIGH-VOLTAGE SECTION

3.5.1 Cathode and Collector Supplies

The high-voltage section begins with the heater and high-voltage transformers that provide the voltage isolation between the TWT electrode voltages and the electronic regulator and control circuitry. The schematic for this section is shown in Figure 3.5-1.

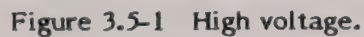
The primary regulator provides the 100-V regulated bus voltage to the center tap of the high-voltage transformer primary. This is the power source for both the beam and depression supplies, which are derived from four separate windings of the high-voltage transformer. The ratio between these windings establishes the exact collector depression ratio required for each TWT.

The high-voltage transformer is driven by Q11 and Q12 as a dc converter. These FETs get their drive from terminals 13, 14, and 15 of A2T3 (auxiliary transformer). The ac output is then rectified to produce the bias voltages from each secondary. The outputs from each secondary are added in series to produce the voltages required to operate the TWT.

The dc voltage produced is passed through the active filter, comprising A3Q1, A3Q2, and A3C7, to reduce the switching frequency ripple. Line frequency ripple is reduced through the primary and helix regulators.

3.5.2 Heater Supply

The primary drive for the heater transformer is produced in parallel with the primary of the auxiliary transformer driven by Q9 and Q10. A sample of this primary center tap voltage is fed back to U2 Pin 1 to regulate the heater voltage. The PWM IC, U2, drives the switching IC, U4, to produce a constant voltage for the heater and auxiliary circuits. This voltage is alternately supplied to each side of the heater transformer to produce the heater ac, which is then rectified and filtered on the high-voltage printed circuit board, A3, by A3CR17, A3CR18, and A3C6. The heater voltage is negative with respect to the cathode for suppression of electrolysis effects on TWT life.



3.6 HELIX REGULATOR

The precision cathode-to-helix voltage is regulated by the cathode/helix regulator, commonly called the helix regulator (see Figure 3.6-1). The high-voltage stack is made up of all of the outputs of the high-voltage transformer, tied to ground through the helix regulator. The regulator has a dynamic range of approximately 300 volts and is normally operated with the collector of transistor Q16 at approximately 150 volts. Transistor Q16 is a high-voltage transistor connected in a common-base configuration. Transistor Q15 provides current gain, and operational amplifier U8 provides the high dc-voltage gain required to maintain the good cathode regulation. Diode VR10 limits the voltage across transistor Q16 and provides a path for current discharge in case of an arc. Diode VR11 is a precision, temperature-compensated voltage reference for the regulator. Ground G3 is an isolated ground used only in helix regulation. The helix or body current of the TWT, which must return to ground G2, flows through resistor R101, R38, 84, or 85 connected between G3 and G2. The voltage developed across the selected resistor represents the helix (I_w) telemetry current. The remainder of the circuit is described in Paragraph 3.7.4

3.7 CONTROL AND PROTECT LOGIC

3.7.1 Turn-On Sequence

Following the application of prime power by connecting an ac power source to the rear of the unit, the power is applied to the front-panel power switch only. Figure 3.2.1 shows the prime power routing and the front-panel control.

When the front-panel switch is closed, prime power is routed to the auxiliary transformer T1 and also to the primary regulator, which is inhibited until an operate command is received. The auxiliary regulator is energized and supplies all of the auxiliary voltages discussed in Paragraph 3.2.2. Nothing further can happen until the heater warm-up time delay has been completed. The logic continually monitors the status of all four faults, and if all are clear at completion of the heater time delay, a ready signal enables the operate circuitry, but the unit will remain in standby until the front-panel switch is closed. If the operate switch has been closed prior to the completion of the heater time delay, the unit will automatically cycle to operate at the completion of the time delay.

3.7.2 Heater Warm-Up and Fault Summary

The heater warm-up time delay is set to be a minimum of 3.0 minutes (6.0 minutes for H11 and H12 models). The schematic for the heater time delay and fault indicators is shown in Figure 3.7-1. The 3-minute delay is determined by the U13 input network. The function of CR47 is to discharge the 3-minute timer in the event of a line loss.

The summing circuit for the faults is sensed as shown in Figure 3.7-1 and summed using diodes CR43 through CR46 into the input of U9-C. All faults are self-resetting, except the helix current fault, which is discussed in Paragraph 3.7.4.

3.7.3 Operate Command

The operate command is enabled when transistor U10B is turned on. As shown in Figure 3.7-2, this low signal then passes through switch A1S2 to illuminate the operate

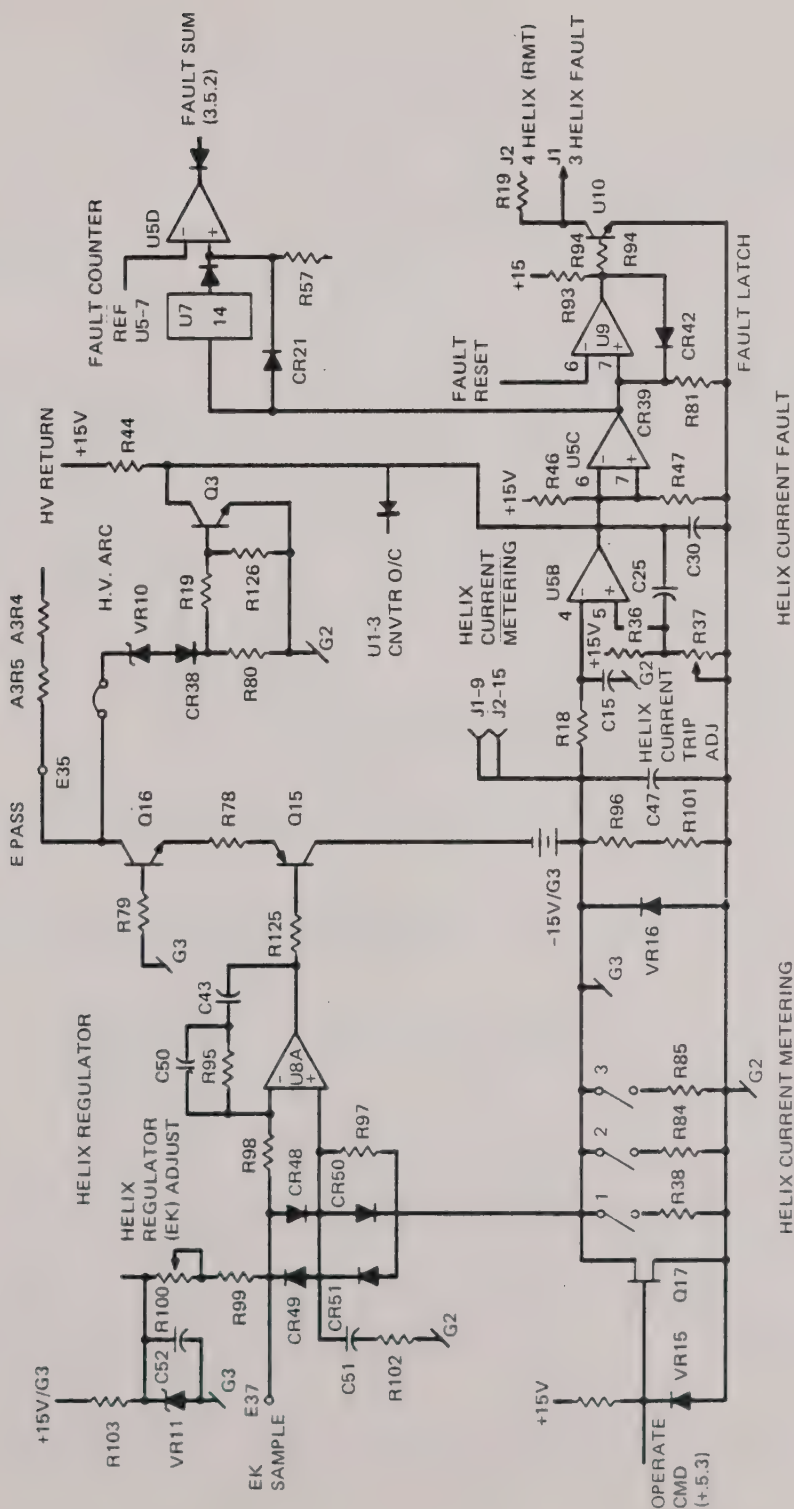


Figure 3.6-1 Helix regulator.



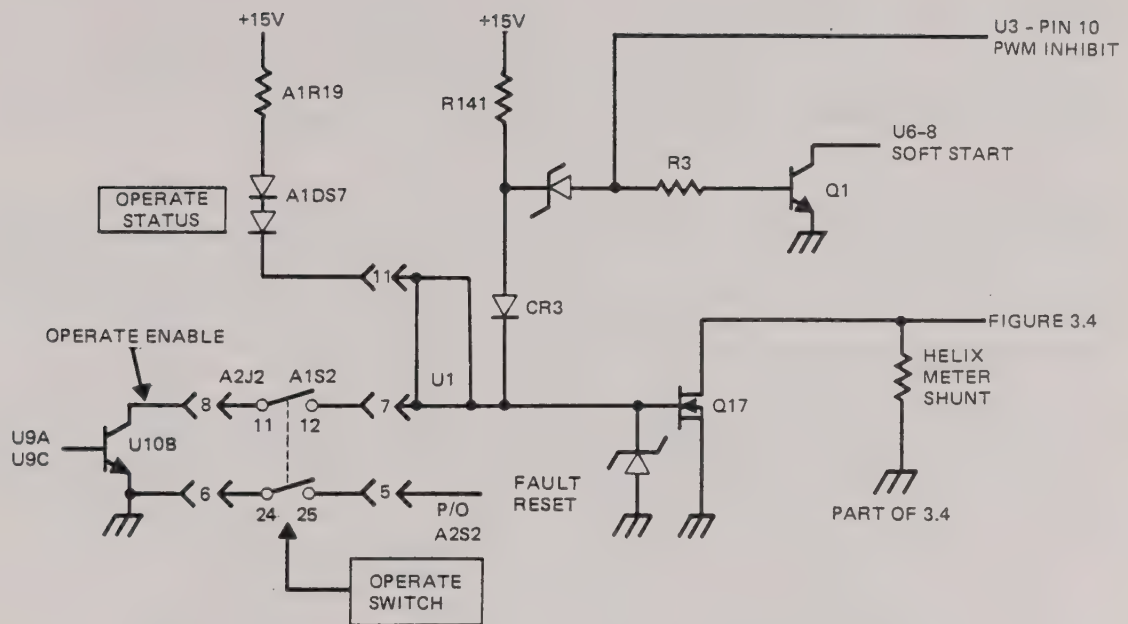


Figure 3.7-2 Operate command.

indicator, enable the primary regulator A2U3, and turn off Q17, which then enables the helix current meter.

A negative temperature coefficient thermistor, whose resistance decreases with heat, limits the in-rush when prime power is applied.

3.7.4 Helix Current Protect

The helix current protect circuit consists of the sampling, metering, latch, fault counter, and indicator circuits shown in Figure 3.6-1.

The helix current protection is the single most important protect circuitry within the TWT. Helix current is the amount of defocused electrons from the beam intercepting the slow-wave structure. Defocusing can occur as the result of improper power supply voltages, RF overdrive, high reflected power at the TWT output, and other conditions, such as interference due to a strong external magnetic field. The object of the protect circuitry is to limit the amount of time during which defocused electrons can intercept the slow-wave structure. This protection circuitry must be fast acting in the event of excessive interception, but tolerant of normal intercept currents that are due to TWT aging and turn-on/turn-off characteristics.

The helix current passes through the helix regulator (Paragraph 3.6) and the return of the negative 15-volt bias power supply to the helix current sensing circuit. Ground G3 is the

floating side of this helix current sensing circuit, the other side is chassis ground. Therefore, helix current is proportional to the voltage at G3 with respect to chassis ground. Resistors R38, R84, R85, R96, and R101 are selected to yield 5 volts full scale on the helix current meter. Check the parts list to determine the exact values for your model. The voltage from this sense circuit is routed to both the metering circuitry contained on the front-panel display board (Paragraph 3.6) and the helix current fault-detection circuitry located on the regulator board.

Operational amplifier U5-A is used to compare the sensed voltage at G3 to the trip level set by divider R36 and potentiometer R37. The output from this comparator is OR'd with the output of the high-voltage arc sense circuit. A low from either circuit will cause U5C to switch states. U5C provides noise immunity to the circuit and drives both the fault counter and the fault-latch circuitry. The fault latch retains the fault indicators, even if the fault clears and resets with the automatic cycling.

The fault counter is factory set to allow two automatic recycle attempts before latching off. The output from U7 is then passed through U5D, which provides a buffer stage to the fault summing network. The U7 output will latch when the selected number of faults has occurred. A manual reset is then required.

The helix current metering circuitry will be discussed in Paragraph 3.8.

3.8 FRONT PANEL DISPLAYS

The front-panel displays are all contained on a single printed circuit card. The schematic shows the three basic functions of the display board. The first section is the operating and fault status LED indicator circuit, which includes DS3 through DS9 and their associated circuitry, as shown in Figure 3.8-1.

The second function, analog-to-digital conversion, is accomplished with U1, as shown in Figure 3.8-2. The digital information thus obtained is used to drive the meter display chip DS1. Potentiometer R2 is used to calibrate the A/D converter for 5.0 volts full scale (Figure 3.8-3).

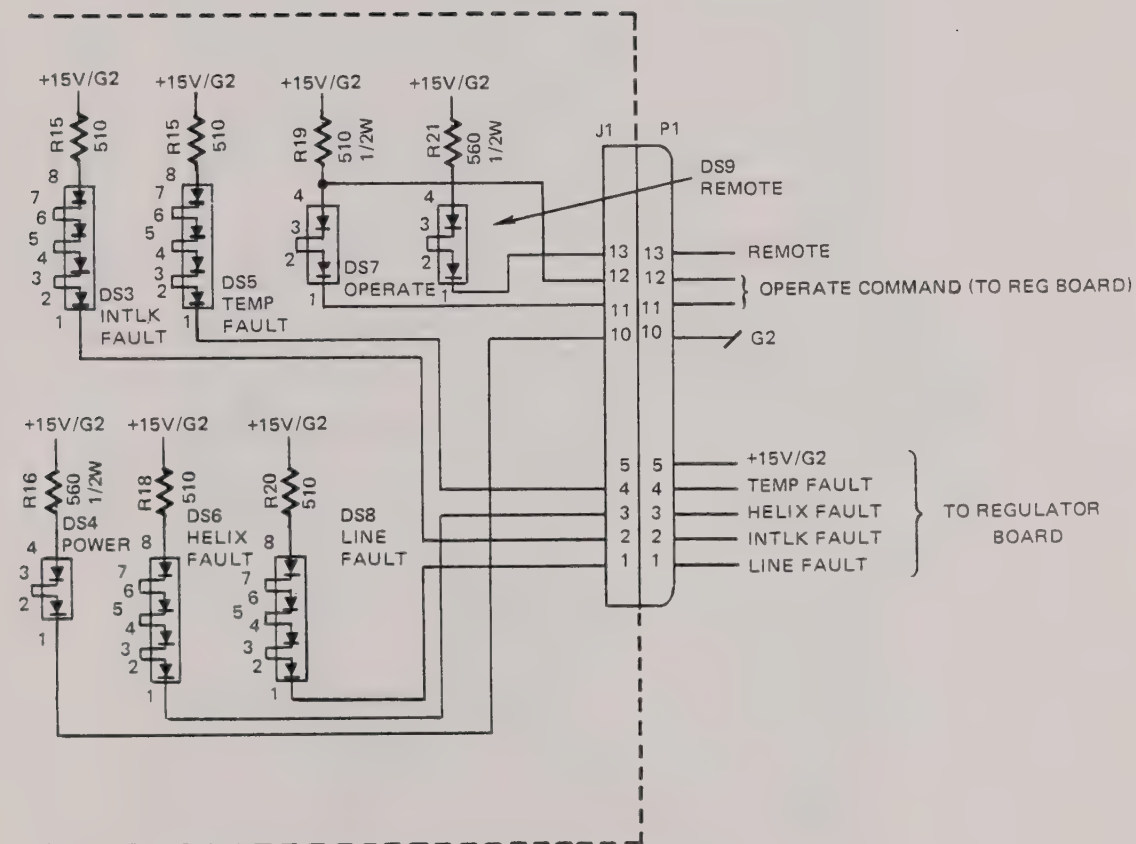


Figure 3.8-1 Operate and fault status.

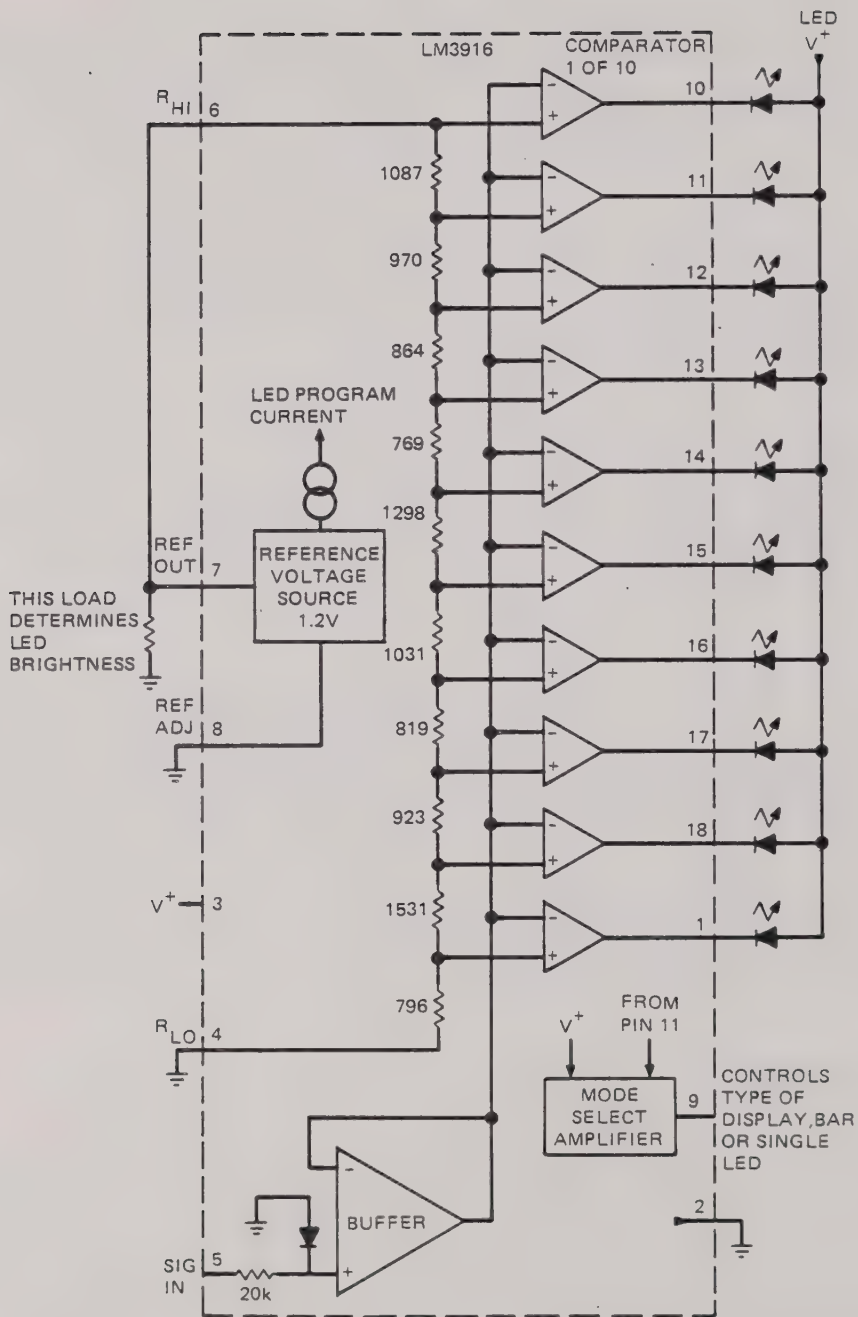


Figure 3.8-2 Analog to digital converter.

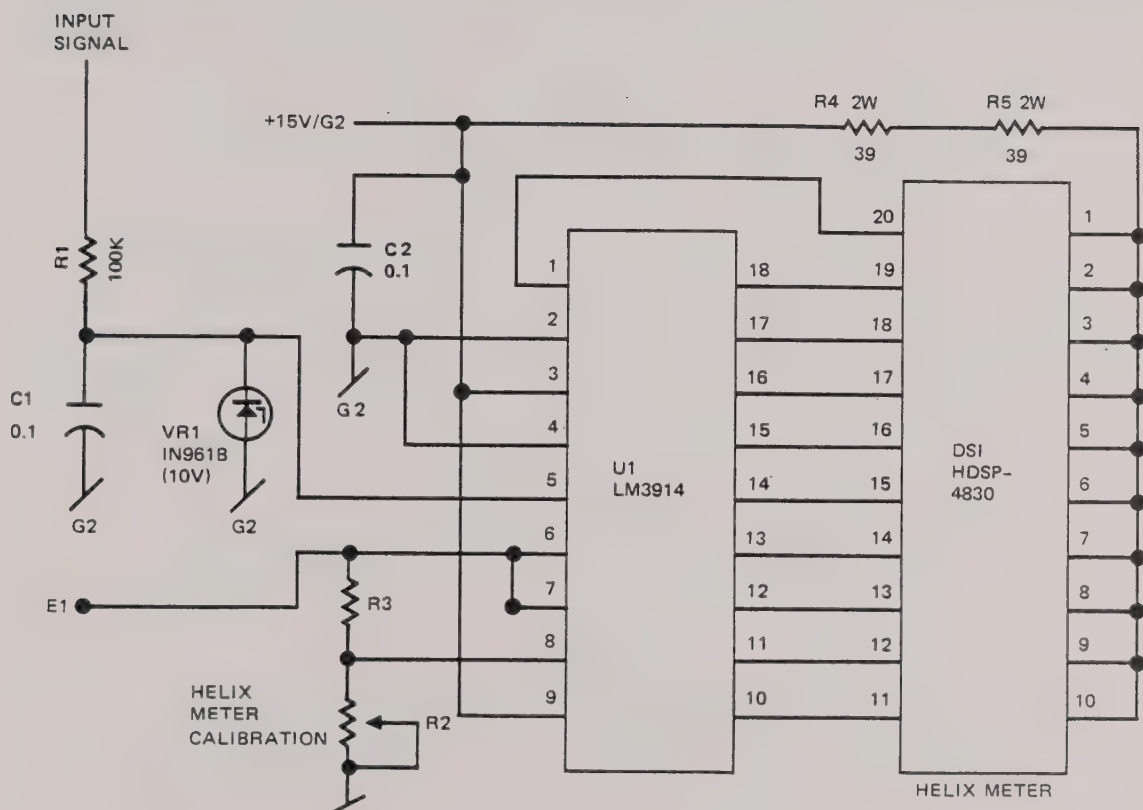


Figure 3.8-3 Metering circuit.

4.0 PREVENTIVE MAINTENANCE

4.1 INTRODUCTION

This section contains instructions for routine operator maintenance and operator replacement of common parts. If trouble does occur in the TWT or power supply, corrective maintenance should be performed immediately to prevent further damage and to restore the instrument to proper operation. See Section 5.0 for troubleshooting and maintenance instructions.

NOTE

Each unit is warranted for one year. Repairs attempted during this warranty period **may** invalidate the warranty.

4.2 ROUTINE MAINTENANCE

The Hughes series of TWT amplifiers is designed for years of trouble-free operation. In the ordinary laboratory environment, no routine maintenance is required, other than periodic cleaning of the air filter; however, in an extremely dusty or humid environment, such periodic maintenance procedures as visual inspection and routine cleaning may be required.

WARNING

Persons who have implanted cardiac pacemakers should completely avoid exposure to microwave radiation.

WARNING

Lethal voltages exist in the operation of this amplifier. Remove all facility power connections before opening the amplifier chassis.

WARNING

Exposure of the human body to microwave radiation of more than 1 milliwatt per square centimeter is unsafe. Operators are warned not to look directly into an open port or waveguide section while the amplifier is operating.

4.2.1 Visual Inspection

Visual inspection of the amplifier at regular intervals will ensure detection of wear or damage, the proper correction of which will prevent equipment malfunction or failure. Inspection should include visual checks for corrosion, deterioration, fungus, excess moisture, and mounting integrity. Visual inspection items are listed in Table 4.2-1.

TABLE 4.2-1
VISUAL INSPECTION ITEMS

Potential Fault	Corrective Procedures
Connectors damaged or improperly seated in mating	Replace connector plugs, mate replacement plugs properly
Electrical wiring broken, burned, or frayed	Repair or replace affected wires
Soldered connection corroded, cracked, or dirty	Clean and resolder
Dirt buildup or moisture causing arcing, short circuits, corrosion, or overheating	Clean (see Section 6.3)

WARNING

When using cleaning solvents, be sure to provide adequate ventilation and avoid breathing the fumes.

4.2.2 Routine Cleaning

The necessary materials and proper procedures for cleaning the amplifier are given in Table 4.2-2.

In an extremely dusty environment, it may be necessary to periodically flush the fan and heat sink with isopropyl alcohol.

TABLE 4.2-2
ROUTINE CLEANING PROCEDURE

Item	Procedure
Chassis	Clean with lint-free cloth, small vacuum, or low-pressure compressed air.
Front panel	Use a dry, clean cloth, a soft-bristle brush, or a cloth saturated with isopropyl alcohol or similar cleaning fluid. Use a Kimwipe (or equivalent) tissue and GTC (or equivalent) glass-cleaning compound.
Wire bundles and wiring	Clean with a soft-bristle brush, small vacuum, or compressed air.
Connector jacks and plugs	Remove dust and dirt with soft-bristle brush or lint-free cloth. Remove corrosion.
Solder connections	Remove dirt with isopropyl alcohol. Remove corrosion by lightly burnishing with a crocus cloth, then clean with a lint-free cloth.
Waveguide assemblies,	Clean with a lint-free cloth moistened with clamps, cables, and a warm soap and water solution. Wipe with rubberized or plastic clear water and dry. Use low-pressure air, parts if available.
Air filters	Remove and wash with warm, soapy water. Air dry (or use low-pressure air if available).
Power supply modules	Remove dust, using a brush or a vacuum cleaner with a brush attachment.

5.0 OPERATOR EVALUATION AND REPAIR

5.1 INTRODUCTION

This section contains instructions for testing, troubleshooting, and servicing the 8001H, 8010H, and 8020H TWTAs. Please note that the entire unit is under warranty for one full year and that the warranty may be invalidated by unauthorized repairs during this one-year period. If a malfunction does occur in the TWT or power supply, corrective maintenance should be performed immediately to prevent further damage and to restore the instrument to proper operation. See Sections 5.5 and 5.6 for troubleshooting instructions.

5.2 MICROWAVE CHECK

To test the microwave performance of the TWT, the test equipment shown in Table 5.2-1 is recommended.

To check RF performance, connect the TWT and related equipment as shown in Figure 5.2-1.

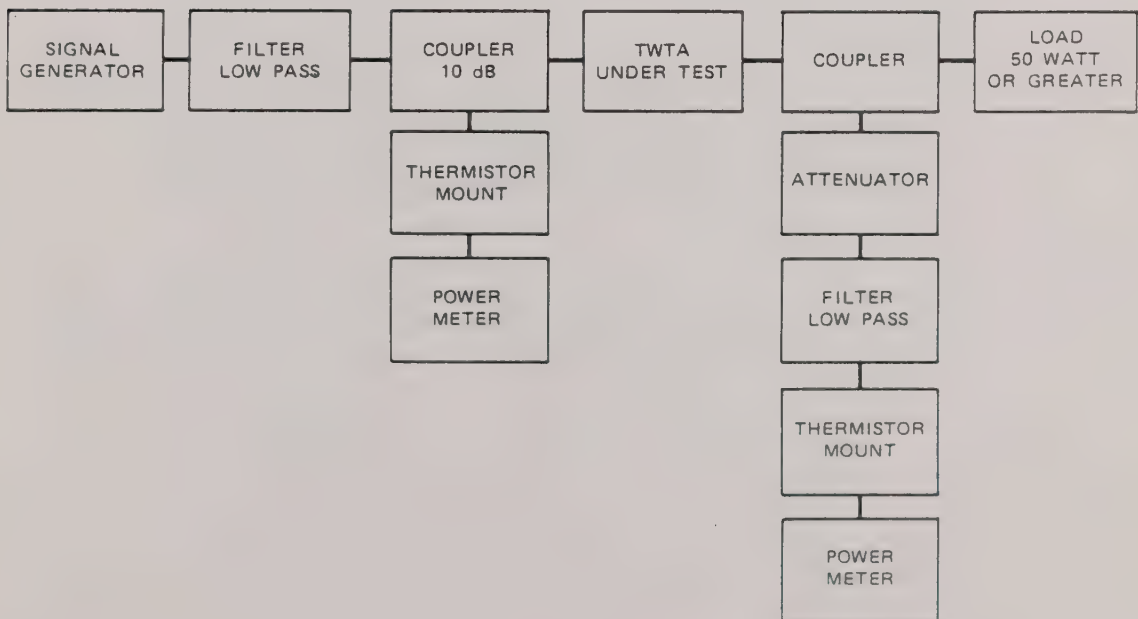


Figure 5.2-1 Typical test setup for RF performance.

TABLE 5.2-1
RECOMMENDED EQUIPMENT FOR RF TEST

Description	L Band 1 to 2 GHz	S Band 2 to 4 GHz	C Band 4 to 8 GHz	X Band 8 to 12 GHz	Ku Band 12 to 18 GHz	K Band 18 to 27 GHz	Ka Band 27 to 40 GHz
Signal Generator (Main Frame)	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.
Plug in	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.
Thermistor Mount (2)	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.
Power Meter (2)	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.
Load	NARDA	NARDA	NARDA	NARDA	NARDA	Microlab	Microlab
10 dB Coupler	NARDA	NARDA	NARDA	H.P.	H.P.	Hughes	Hughes
20 dB Coupler	NARDA	NARDA	NARDA	H.P.	H.P.	Hughes	Hughes
30 dB Coupler	NARDA	NARDA	NARDA	H.P.	H.P.	Hughes	Hughes
10 dB Attenuator	NARDA	NARDA	NARDA	H.P.	H.P.	Hughes	Hughes
Low Pass Filter (2)	Microlab LA-20N or LA-30N	Microlab LA-40N	Microlab LA-80N	H.P. (WR90)	H.P. (WR62)	Gamma-F LPF-42	Gamma-F LPF-28

Turn on all equipment and allow sufficient time for power meters to stabilize, then perform the RF test as defined in the following section.

Step 1 - Set the signal generator to desired frequency.

Step 2 - Start at a low RF drive level and increase input power until maximum deflection occurs on the RF output power meter. If the tube is accidentally overdriven with RF, the helix current will increase and may trip the helix protect circuit. If this should happen, reduce the RF drive level and then reset the unit by turning the Operate switch to standby and then back to operate.

Step 3 - The readings should be less than 10 mW of input RF power and more than 10 watts of RF output power for the 10-watt tubes, or less than 20 mW of input RF power and more than 20 watts of RF output power for the 20-watt tubes.

5.3 POWER SUPPLY TEST

Test of the power supply is potentially hazardous and should be attempted only if the RF performance is not within specification, and then **only** by **skilled** electronic test personnel familiar with high-voltage hazards. To verify proper operation of the power supply, the following procedure should be followed, using equipment equivalent to that in Table 5.3-1.

Step 1 - Remove the line cord from the rear of the unit.

Step 2 - Remove the cover of the instrument.

CAUTION

The high-voltage board contains lethal voltages up to 7,000 volts. Exercise extreme caution when working on or around this circuit. Use high-voltage insulated test probes and do not touch any metal parts or printed circuitry.

Step 3 - Reconnect the line cord and plug into ac outlet. Turn on POWER switch and allow for 3-minute time delay. The cover interlock switch must be allowed to inhibit the high voltage. Do not turn on OPERATE switch at this point.

TABLE 5.3-1
RECOMMENDED TEST EQUIPMENT FOR POWER SUPPLY

Description	Test Equipment
1000:1 voltage divider (5 kV max.)	
10000:1 voltage divider (over 5 kV)	
Digital Multimeter	Fluke 8012A
Variable Transformer	Superior VS116B
TWT Load Simulator	HAC 1607HA

CAUTION

RF output must be terminated with an RF load whenever high voltage is on to prevent damage to the TWT. The high voltage may be switched off by turning the RF switch off. This is recommended when connecting test probes to the high-voltage module.

NOTE

The following measurements are made on either the high-voltage module (A3) or regulator board (A2). All measurements are made with respect to terminal E1 (which is chassis ground), except the heater voltage. All voltages should correspond to the voltages indicated on the TWT label or data sheet. If any voltages do not correspond, please refer to Section 5.6 for the proper adjustment procedure.

Step 4 - Measure the anode voltage on terminal A2E41.

WARNING

The heater floats at cathode potential (up to 7000 volts) when the high voltage is on.

Step 5 - Using an isolated voltmeter, such as a Fluke 75, measure the heater voltage from A3E16 to A3E12. The heater voltage is dc. Alternatively, measure the heater voltage with the unit in standby mode (no high voltage on).

Step 6 - Defeat the interlock switch and activate the OPERATE/STANDBY switch.

Step 7 - Using 1,000:1 divider or meter capable of measuring 5000 volts, measure the collector voltage on terminal A3E17.

Step 8 - Using 10,000:1 divider or meter capable of measuring 7000 volts, measure the cathode voltage on terminal A3E16.

NOTE

Using a voltage divider of less than 25 megohm input Z may cause the helix current fault circuit to latch.

5.4 TROUBLESHOOTING GUIDE

Some of the indications of instrument failure are shown below in Table 5.4-1. In general, "wear out" or "end of life" of the traveling-wave tube is evidenced by a dropping of power output when traveling-wave tube voltages are properly set.

TABLE 5.4-1
TROUBLESHOOTING GUIDE

Symptom	Possible Cause
No POWER ON light with Power switch on	Blown fuse, improper line voltage, unit set in remote mode. Auxiliary regulator failure
Power switch on, no OPERATE light after 6 minutes with operate switch depressed	Fault Lamp illuminated Logic failure
Operate lamp "on" immediately after application of power	IC U10 shorted U9 defective
Unit cycles "on" and "off"	Blower failure (temp. indicator) Excessive ambient temperature (temp. indicator) Soft line-voltage source (line fault flash)
High helix current indicator	Excessive RF drive/incorrect frequency Misadjusted tube voltages Traveling-wave tube defective High load VSWR Microwave loop oscillation
No helix current	No high voltage Traveling-wave tube defective No TWT heater voltage
RF output without RF input	Traveling-wave tube oscillating Voltages misadjusted/high load VSWR External microwave feedback
Fuse blown	S1, T1, CR1, A2U4 and/or A2Q4, 8, 11, 12 shorted. Incorrect voltage applied

5.5 TROUBLESHOOTING PROCEDURE

(Refer to Schematic Diagram and assembly drawings of individual PC boards).

If a problem is observed or suspected in the TWT, DO NOT OPERATE THE UNIT until proper operation has been verified by following this test procedure. Operation of a malfunctioning unit may cause additional damage to the TWT.

NOTE

The unit is under warranty for one full year from date of purchase. It is recommended that malfunctioning units during this one-year period be returned to the factory for repair or replacement. Unauthorized attempted repair during this period may invalidate the warranty.

CAUTION

The input circuitry is operated directly from the ac line with no isolation. Use an isolation transformer (rated 500 V-A or greater) or float all line-operated test equipment. Failure to observe this caution/note will cause serious damage to the power supply and possibly to the TWT and to the grounded test equipment.

5.5.1 Initial Setup

Step 1 - If RF performance is not as specified at the high or low end of the specified band, consult the factory. Follow the procedure of Section 5.3 to check the power supply voltages against the TWT labeled values. Slight adjustments in these voltages may be made to optimize performance at the band limits after factory consultation. Refer to the adjustment procedure in Section 5.6.

If a fuse is blown or if some catastrophic failure is suspected, follow the procedure below to prevent further damage.

Step 2 - Disconnect the ac line cord.

Step 3 - Remove the cover.

Step 4 - Check the resistance from drain to source of Q4 and Q11. It should read an open circuit. (If not, Q4, Q8, Q11, and/or Q12 is damaged or shorted. Remove them from the heat sink and recheck each transistor individually, replacing all of them if any are damaged. If they are good, test CR54, VR7, VR9, and any component on that line.

Step 5 - Disconnect all TWT leads and connect resistive loads per Figure 5.5-1 or per Hughes 1607HA load bank.

5.5.2 Testing the Auxiliary Converter

Step 1 - Connect a lab supply positive to A2CR5 cathode and negative to A2CR6 anode. Be sure that the ac line voltage is not connected.

Step 2 - Connect a digital multimeter from A2TP8 to chassis ground and set up to read 48 VDC, maximum.

Step 3 - Slowly raise the lab supply voltage while watching the input current and the A2TP8 voltage. The input current should not exceed 1 A, and the A2TP8 voltage should level off in the range of 14 to 17 volts, depending upon the TWT heater requirement. If the current exceeds 1 A, check Q9, Q10, VR6, CR19, CR20, all output circuits, and loads to A2T3 and T3 (heater transformer). If the voltage at A2TP8 does not regulate, check U2, U4, and VR6.

If no failure is detected above, continue raising the lab supply voltage until the line-voltage fault lamp goes out. From the point of regulation, the input current should decrease as the input voltage is raised, and the A2TP8 voltage should remain stable.

Step 4 - Connect an oscilloscope to TP9 and TP10; verify that a clean 28 to 36 volt peak-to-peak square wave at 15 KHz exists. If the signal is not stable, check all drive circuits to Q9 and Q10. If the signal is not clean, check all circuits on the outputs of A2T3 and T3.

Step 5 - Check that all output voltages from A2T3 and T3 are correct.

5.5.3 Testing the Primary Regulator

Step 1 - The resistive load should be connected. See Paragraph 5.5.1, Step 5.

The auxiliary regulator should be running on a lab supply. See Paragraph 5.5.2.

Reconnect the unit to the ac line through a variable transformer and monitor the input voltage and current. The input is fused at 6 A (3 A for 220 VAC units).

Step 2 - Connect a high-voltage divider capable of reading -7000 VDC from A3E16 (cathode voltage) to chassis ground.

PARAMETERS	TUBE LOAD	417HD 419HD	418H	564H	568H	640H 648HD	771HD 783H 785HD	848HA 848HD	848HB 889H 856H	911H	912H	670HA	991H 992H
		2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W
ANODE	RA	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W	2.0 M 1 W
I_{HTR} 0.300 to 0.450 A	RH	—	—	16 Ω 5 W	16 Ω 5 W	20 Ω 5 W	20 Ω 5 W	—	—	16 Ω 5 W	16 Ω 5 W	—	—
I_{HTR} 0.700 to 0.850 A	RH	9 Ω 10 W	9 Ω 10 W	—	—	—	—	9 Ω 10 W	9 Ω 10 W	—	—	9 Ω 15 W	9 Ω 10 W
With Depression	RK	250 K to 330 K 25 W	250 K to 330 K 25 W	—	130 K to 220 K 25 W	1.2 M to 9.0 M 25 W	1.3 M to 7.5 M 25 W	2.4 M to 7.2 M 25 W	2.8 to 8.6 M 25 W	3.0 to 3.6 M 5 W	—	1.2 M to 9.0 M 25 W	13 M to 132 M 25 W
With No Depression	RK	—	—	17 K to 25 K 200 W	—	—	—	—	—	—	—	—	—
Cathode Voltage Collector Voltage = 50% Depression Voltage	RC	—	—	—	—	18 K to 25 K 200 W	36 K to 43 K 200 W	35 K to 43 K 200 W	30 K 39 K 200 W	130 K to 160 K 50 W	175 K 75 W	18 K to 25 K 200 W	72 K 150 W
Collector = 400 to Voltage 650 volts	RC	12 K to 16 K 200 W	8 K to 10 K 300 W	—	12 K to 16 K 200 W	—	—	—	—	—	—	—	—

Note: Due to design changes and individual TWT characteristics, TWTs may operate at voltage and current configurations requiring different resistive values from those listed in the above table. Please refer to the data sheet supplied with the TWT or amplifier unit being tested for correct voltages and currents. Consult the above table for the most appropriate values for resistive loads. Please contact the factory if there is any doubt as to the correct values to use.

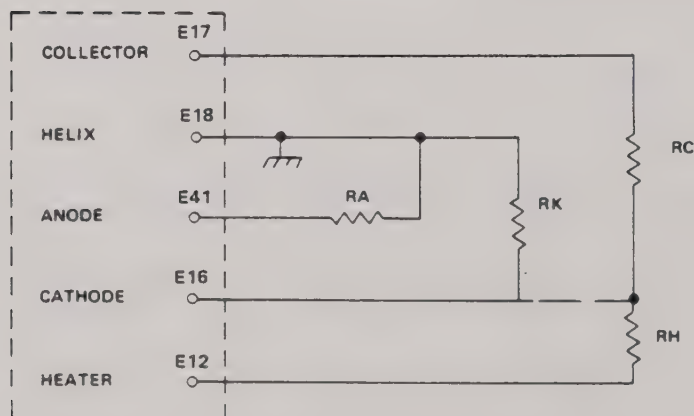


Figure 5.5-1 Resistive load.

Step 3 - Connect a battery-operated DVM from A2VR23 cathode (+) to A2VR23 anode (-) and set up to read 90 to 110 VDC.

CAUTION

The VR23 anode is NOT chassis ground. It can be anywhere from -70 to -160 VDC referenced to chassis ground.

Step 4 - Turn on the operate switch, and SLOWLY raise the input line voltage while monitoring input current, A2VR23 voltage, and cathode voltage. DO NOT ALLOW THE INPUT CURRENT TO EXCEED 4 A.

The VR23 voltage should regulate between 90 and 110 VDC, and the cathode voltage should regulate at the TWT label voltage.

If the input current exceeds 4 A or no voltages come up, all circuits from the input rectifier CR1, through the downconverter (Q4/Q8), the chopper (Q11/Q12), all protection diodes and zeners, and the high-voltage rectifiers on the high-voltage board (A3) must be checked. A simple short-or-open circuit check of the major power-handling component should reveal the problem.

If the converter does not regulate, the four power FETs, CR34/35, and U6 should be checked.

5.5.4 Testing the Helix Protect Circuit

Step 1 - Turn the power switch off and connect normal line power.

Step 2 - Remove A2Q17.

Step 3 - Connect a 10-volt minimum lab supply, set to zero volts, across A2VR16, positive to cathode.

Step 4 - Connect a DVM from U10-11 to chassis ground and set up to read 15 VDC.

Step 5 - Set the TWTA to POWER ON/STANDBY.

Step 6 - Measure the voltage at TP16.

Step 7 - The voltage at U10-11 should be 15 Vdc, nominal.

CAUTION

Do not allow the lab supply current to exceed 20 mA.

Step 8 - Slowly raise the output of the lab supply. The voltage at U10-11 should drop to about 1 volt when the lab supply exceeds the voltage on TP16.

At 5 volts, the front panel should show a full-scale display for helix current.

Step 9 - Turn the amplifier off, remove the lab supply, and replace A2Q17.

5.5.5 Testing the Helix Regulator Circuit

Step 1 - Turn the unit off.

Step 2 - Monitor the voltage at A2E35 with a voltmeter (0 to 300 volts, minimum).

Step 3 - Turn the POWER and OPERATE switches on and wait 6 minutes for time delay.

Step 4 - With nominal line voltage, the voltage at A2E35 should be about 150 VDC. The range of this voltage is approximately 5 to 300 VDC. If necessary, adjust A2R62 for 150 VDC at A2E35.

Step 5 -If the voltage at A3E35 cannot be adjusted above 5 volts and pin 6 of U8 is negative with respect to ground, Q15 or Q16 is defective. Also check VR10, 19, and CR38 chain.

Step 6 - If the voltage at A2E35 cannot be adjusted below 300 VDC and pin 6 of U8 is positive with respect to ground, Q16 is defective. If the voltage on pin 6 of U8 is negative, either Q15 or Q16 is defective.

5.6 REPLACEMENT OF TWT

Although it is recommended that replacement of the TWT be performed at Hughes Aircraft Company, Electron Dynamics Division, tubes may be replaced in the field by using the following procedures:

Step 1 - Disconnect power from unit.

Step 2 - Remove the cover.

Step 3 - Disconnect the TWT power leads.

Step 4 - Carefully disconnect RF connections and remove the TWT from the amplifier.

Step 5 - Clean the old thermal compound from the heat sink. Apply a **thin** coat to the base of the replacement TWT and physically mount the new TWT.

Step 6 - Connect the RF fittings and replace the rear panel. Route the TWT power leads to the high-voltage module, but do not attach.

Step 7 - Connect the resistive loads per Figure 5.5-1.

Step 8 - Connect a DVM from A2E41 to chassis ground.

Step 9 - Set the TWTA to POWER ON/STANDBY and adjust R71 for correct anode voltage.

Step 10 - Connect the DVM across A3E12 and A3E16 and adjust A2R17 for the correct heater voltage. (Allow 3 minutes for stabilizing.)

WARNING

Failure to do Step 11 will result in damage to the TWTA, the DVM, and present a high-voltage safety hazard.

Step 11 - Disconnect the DVM from A3.

Step 12 - Connect a high-voltage divider from A3E16 (cathode voltage) to chassis ground and set up to read up to -7000 VDC.

Step 13 - Connect a DVM from A2E35 to chassis ground and set up to read +300 VDC.

Step 14 - Adjust A2R100 full counterclockwise; switch the TWTA to operate. Adjust A2R62 to 150 volts less than the required cathode voltage, A2R100 for the exact cathode voltage required, and A2R62 again for 150 volts at A2E35.

Step 15 - Turn POWER and RF switches off, remove the resistive loads, and connect the TWT power leads.

Step 16 - Turn POWER switch on, verify heater voltage, and readjust if necessary.

Step 17 - Turn RF switch on and verify cathode voltage reading. Readjust if necessary.

Step 18 - Perform microwave check per Section 5.3. Additional fine adjustment may be required. RF power output or gain may be optimized by adjustment of the tube voltages. Consult Factory.

NOTE

If TWTs have been stored for more than one year, the RF output power may initially be low. Allow the TWT to run for a minimum of 12 hours. The RF power output should be as specified.

6.0 UNPACKING, INSPECTION, INSTALLATION, AND REPACKING

6.1 GENERAL

The Hughes 8000H series of TWT amplifiers is designed to operate in ambient temperatures from 0 to 50°C (32 to 122°F). Even so, to maximize instrument life, it is recommended that the equipment be maintained at or near 21°C (70°F), with a relative humidity of under 95 percent (no condensation).

6.2 UNCRATING AND INSPECTION

Before uncrating, inspect the outside of the packing container for any evidence of damage. If damage is evident, immediately notify Hughes Aircraft Company, Electron Dynamics Division (EDD), and contact the carrier that delivered the amplifier to submit a damage report. Failure to do so could invalidate possible claims.

6.2.1 Uncrating

Carefully uncrate and remove all items. Take care that all items have been removed before discarding any packing material. Save all packing material until all inspections are complete. If future repacking for shipment or storage is anticipated, save the original packing cartons.

If the shipping container or cushioning materials are damaged, keep them until the equipment has been checked for completeness and the amplifier has been checked mechanically and electrically. Verify that all items listed on the packing slips have been received. Inspect all items for evidence of damage. If damage is evident, immediately contact the carrier that delivered the equipment and file a claim. Failure to do so could invalidate future claims.

6.2.2 Mechanical Inspection

Check the amplifier thoroughly for damaged or loose parts. To remove the top or bottom covers of the amplifier, remove screws around perimeter of cover and slide cover off. After visual inspection is complete, reinstall cover and tighten all screws. If damage is found, file a claim with the carrier.

6.2.3 Electrical Inspection

Check amplifier performance against the data sheet delivered with the unit.

6.3 MECHANICAL INSTALLATION

Hughes amplifiers need only ordinary tools for mechanical installation.

6.3.1 Environmental Limitations

The Hughes family of TWTAs is designed to operate in a temperature environment of 0 to 50°C. A clearance of three inches is recommended at the rear of the instrument to ensure sufficient cooling. Take care not to block the air outlet at the rear of the unit.

Because the amplifier develops high voltage, a dry, dust-free installation area is best. If installed in an excessively dirty area, the unit should be periodically cleaned.

WARNING

The amplifier chassis is grounded via the three-conductor power cord supplied with each TWTA. If used on a two-wire system, alternative grounding of the chassis is required.

6.3.2 Power Requirements

For the protection of operating personnel, the National Electrical Manufacturer's Association (NEMA) recommends that the amplifier assembly panel and cabinet be grounded. The amplifier is grounded when its three-conductor power cable is plugged into a U-blade receptacle. Power requirements are given in Table 1.2-1, on Page 2.

6.3.3 Rack Mounting

The amplifier configuration is designed for bench mounting or mounting in an EIA standard 19-inch rack. For rack mounting, the amplifier assembly needs no special mechanical adaption, other than front-panel tabs. These parts are available for field retrofit and are identified as Option E.

Proceed as follows:

1. Establish the desired front-panel arrangement, allowing sufficient space for ventilation (about 3-1/2 inches), and position the amplifier panel on the rack's front risers.
2. Mount the amplifier to the horizontal rails secured to the rack.

NOTE

Horizontal rails to support the amplifier are strongly recommended in applications in which the rack experiences shock or vibration.

6.4 REPACKING FOR SHIPMENT OR STORAGE

6.4.1 General

Hughes Electron Dynamics Division (HEDD) cannot be liable for damage incurred in the return shipment of any TWT Amplifier. The following instructions are a general guide for repacking the amplifier to minimize such damage. Procedures to be followed in the case of return under warranty are covered in Chapter 7.0 of this manual. If there are any questions, contact the local Hughes representative or Hughes Electron Dynamics Division (HEDD) regarding the return of an amplifier or amplifier part to HEDD.

6.4.2 Repacking

If the original container is available, place the amplifier in the container, making sure that there is adequate packing material around all sides of the unit and that the front panel is protected with cardboard strips.

If the original shipping container and packing material are not available, refer to Figure 6.4-1 and proceed as follows:

1. Wrap the amplifier in heavy paper or plastic.
2. Make or select a box made of heavy wood or no less than a double-wall weight cardboard of a size that will allow at least two inches of space on all sides of the amplifier assembly.
3. Place a foam block, 2-inch thick foam rubber (4- to 6-pound density), in the bottom of the box.

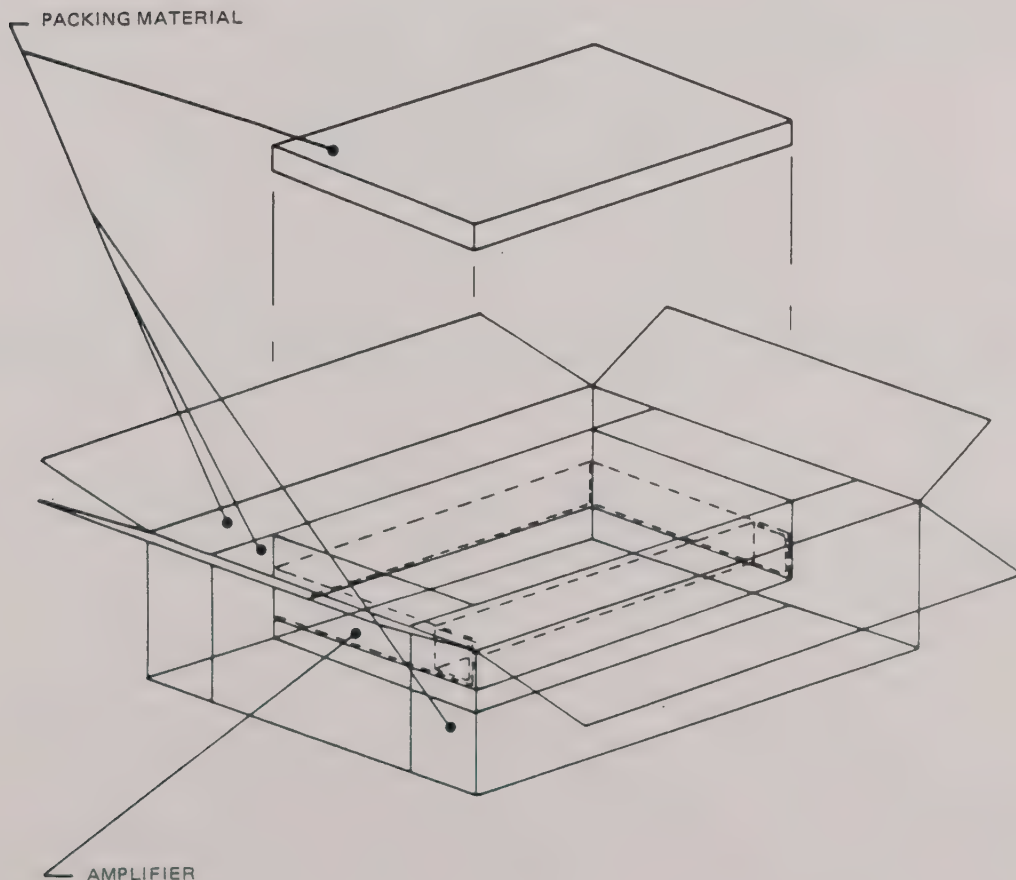


Figure 6.4-1 Packing material, amplifier.

4. Put the assembly in the center of the box and use cushioning material to completely fill the space surrounding the assembly (sides and top).
5. Close the box and tape it closed with metal bands, heavy paper tape, or fiber-reinforced plastic tape.

6.4.3 Marking, Tagging, and Addressing

Mark the packing box **"FRAGILE...DELICATE INSTRUMENT."**

NOTE

If the amplifier is to be shipped to Hughes EDD for service or repair, attach a tag identifying service or repair wanted. A malfunction report form is contained in Section 9.0 for your convenience. The use of this form will expedite product servicing.

Refer to the transmitter by both model and serial number in any correspondence. Please use the following shipping address for all returned products.

**HUGHES AIRCRAFT COMPANY
ELECTRON DYNAMICS DIVISION
3100 West Lomita Boulevard
Torrance, CA 90505
(213) 517-6172**

6.4.4 Shipping

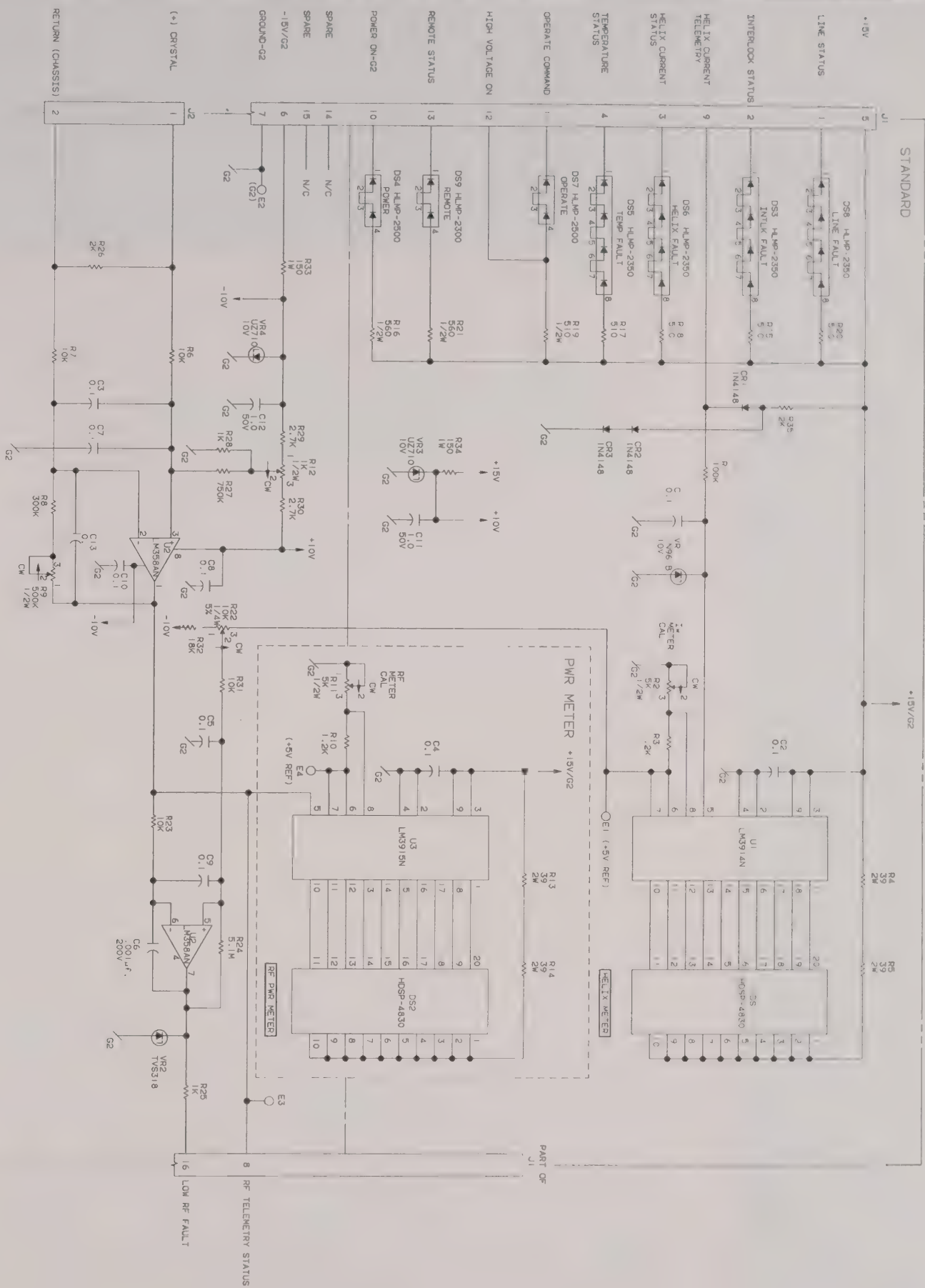
Ship according to the best commercial practice. Again, for additional guidance in returning the amplifier to Hughes EDD, contact Hughes EDD or your local Hughes representative.

6.4.5 Storage

Do not store a Hughes TWT Amplifier unless it has been packed as described in Paragraph 6.4.3. Store amplifier in a clean, dry, indoor location with a temperature ranging from -20 to 70°C (-4 to 160°F).

7.0 SCHEMATICS

Document Number	Title
CHB737507	Display Board
CHB747180	High Voltage Board
CHB750466	Regulator Board
CHB724485	Remote Interface Board



LOW RF POWER

ACTIVITY		REACTANTS	
DATE	TIME	ORGANIC/ION	ANALYST
A	5:00 PM	SC-MA-1C	CB WAS JPC
B	ADDED R20.	CM-GR3	

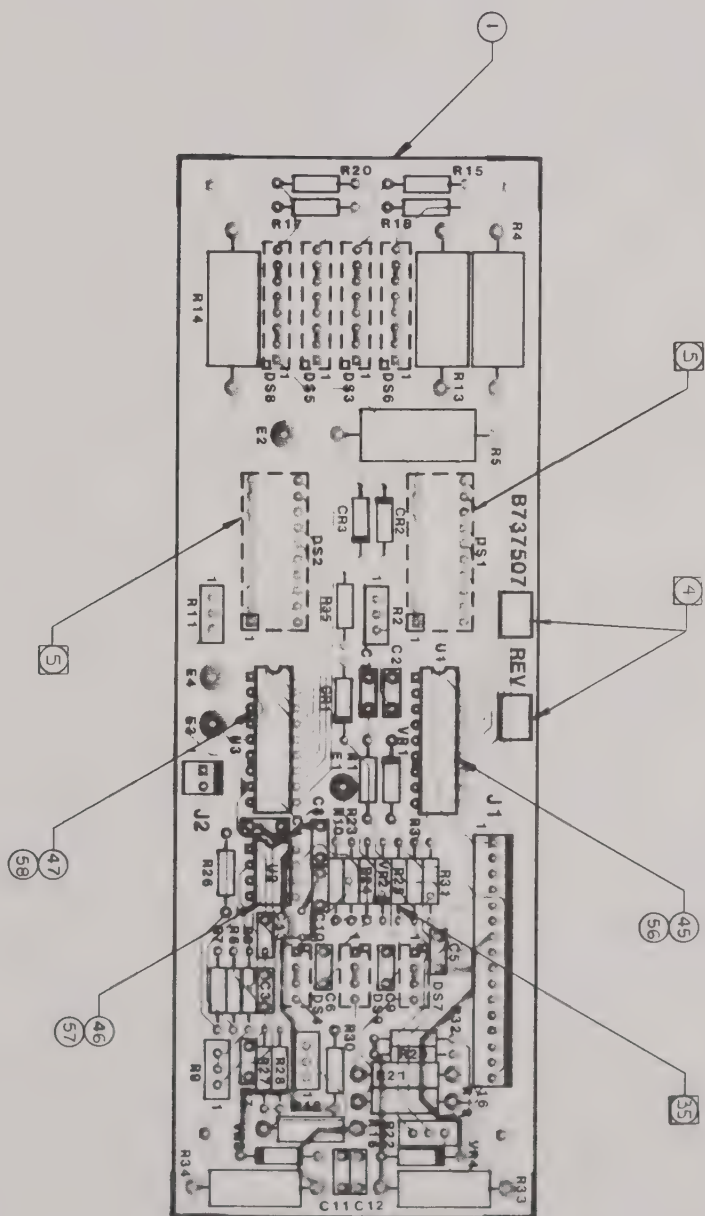
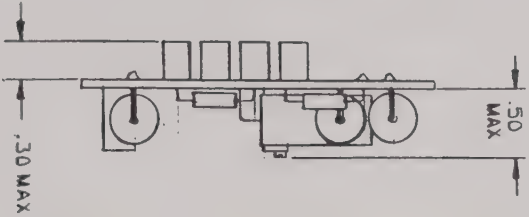
[illegible]

3. -002 SHOWN. FOR OTHER ASSEMBLIES SEE APPROPRIATE PARTS LIST
2. CAPACITORS ARE IN MICROFARADS, $\pm 10\%$, 100V.
1. RESISTORS ARE IN OHMS, $1/4W$, $\pm 5\%$.

NOTES, UNLESS OTHERWISE SPECIFIED

PART NO
B737507-001
-002
-003

8	7	6	5	4	3	2	1
205428	18241	1					
REV	MS	ON DRG	MS				
EFF	AUTHORITY	CONTR	DESCRIPTION	DATE	APPROVED		
B	REVISED AND REDRAWN	2-88	WCU				



-002 SHOWN

1. FOR SCHEMATIC DIAGRAM SEE DWG CHG 737507
2. REFERENCE DESIGNATIONS ARE FOR REFERENCE ONLY AND MAY NOT APPEAR ON PARTS.
3. ASSEMBLE AND SOLDER PER WGS203400
4. MARK PART NO. AND REV LETTER PER HP-5, TYPE I, CLASS 3, GRADE A, FORM 1, 12 HIGH, COLOR WHITE, APPROX. AS SHOWN.
5. DS1 AND DS2 TO BE SPACED .05 OF BD. SURFACE.
6. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND PER ASST 1743
7. STANDARD HOLE TOLERANCES PER ASST 10287
8. FINISH XX 3
9. ANGLE 3
10. DESUR
11. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND PER ASST 1743
12. STANDARD HOLE TOLERANCES PER ASST 10287
13. FINISH XX 3
14. ANGLE 3
15. DESUR
16. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND PER ASST 1743
17. STANDARD HOLE TOLERANCES PER ASST 10287
18. FINISH XX 3
19. ANGLE 3
20. DESUR
21. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND PER ASST 1743
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25. DESUR
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37. STANDARD HOLE TOLERANCES PER ASST 10287
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81. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND PER ASST 1743
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83. FINISH XX 3
84. ANGLE 3
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87. STANDARD HOLE TOLERANCES PER ASST 10287
88. FINISH XX 3
89. ANGLE 3
90. DESUR
91. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND PER ASST 1743
92. STANDARD HOLE TOLERANCES PER ASST 10287
93. FINISH XX 3
94. ANGLE 3
95. DESUR
96. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND PER ASST 1743
97. STANDARD HOLE TOLERANCES PER ASST 10287
98. FINISH XX 3
99. ANGLE 3
100. DESUR

TOOLED NOV 82

DATE/CHG/POST

8

7

6

5

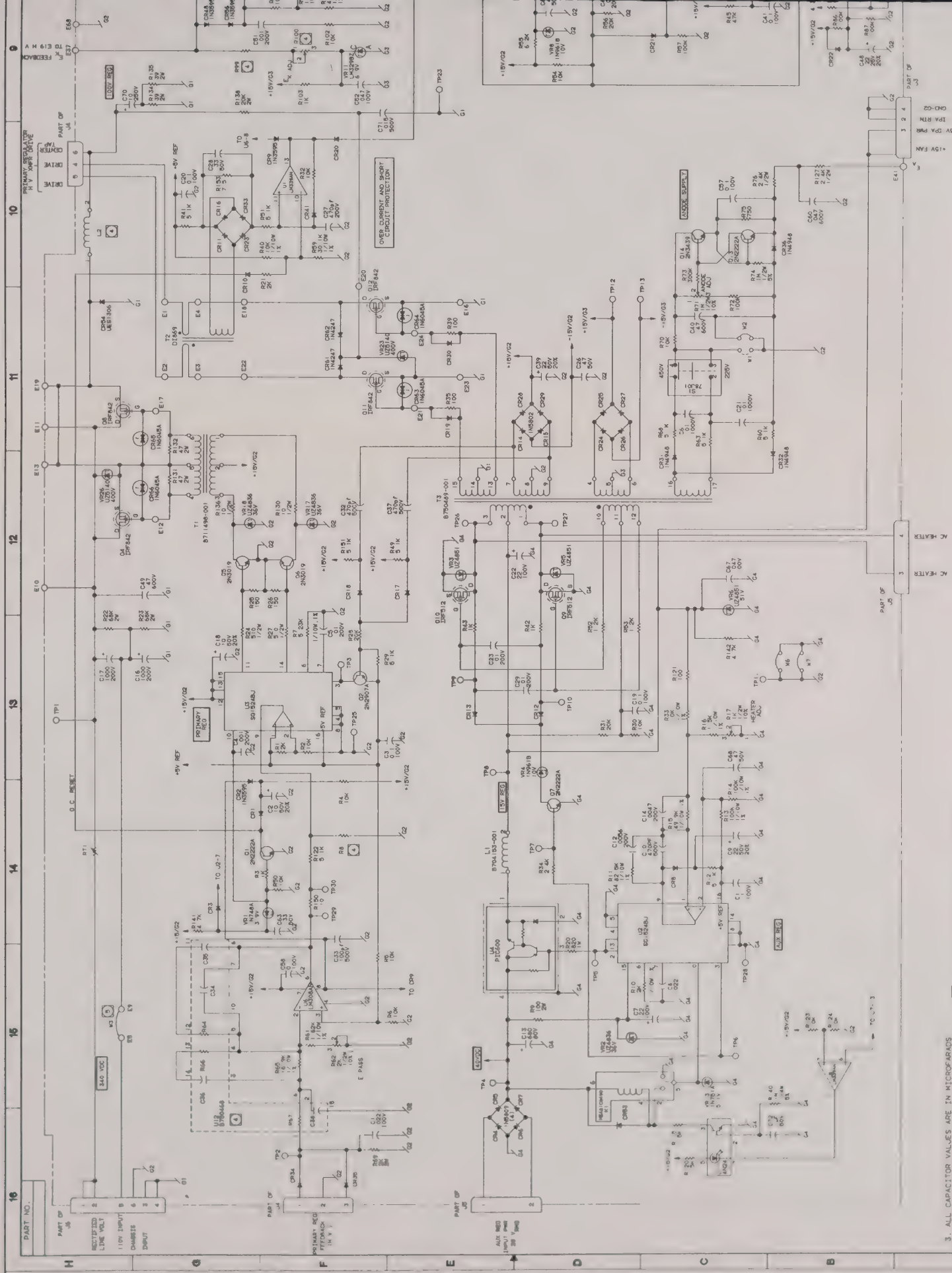
4

3

2

1

10 OF 1



3. ALL CAPACITOR VALUES ARE IN MICROFARADS
100. 65V.
2. ALL DIODES ARE 1N4148.
1. ALL RESISTOR VALUES ARE IN OHMS, 1/10W, 435.
NOTES: UNLESS OTHERWISE SPECIFIED

NOTES: UNLESS OTHERWISE SPECIFIED

NOTES: UNLESS OTHERWISE SPECIFIED

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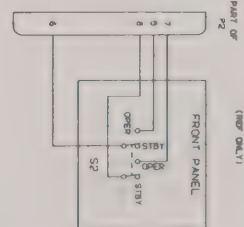
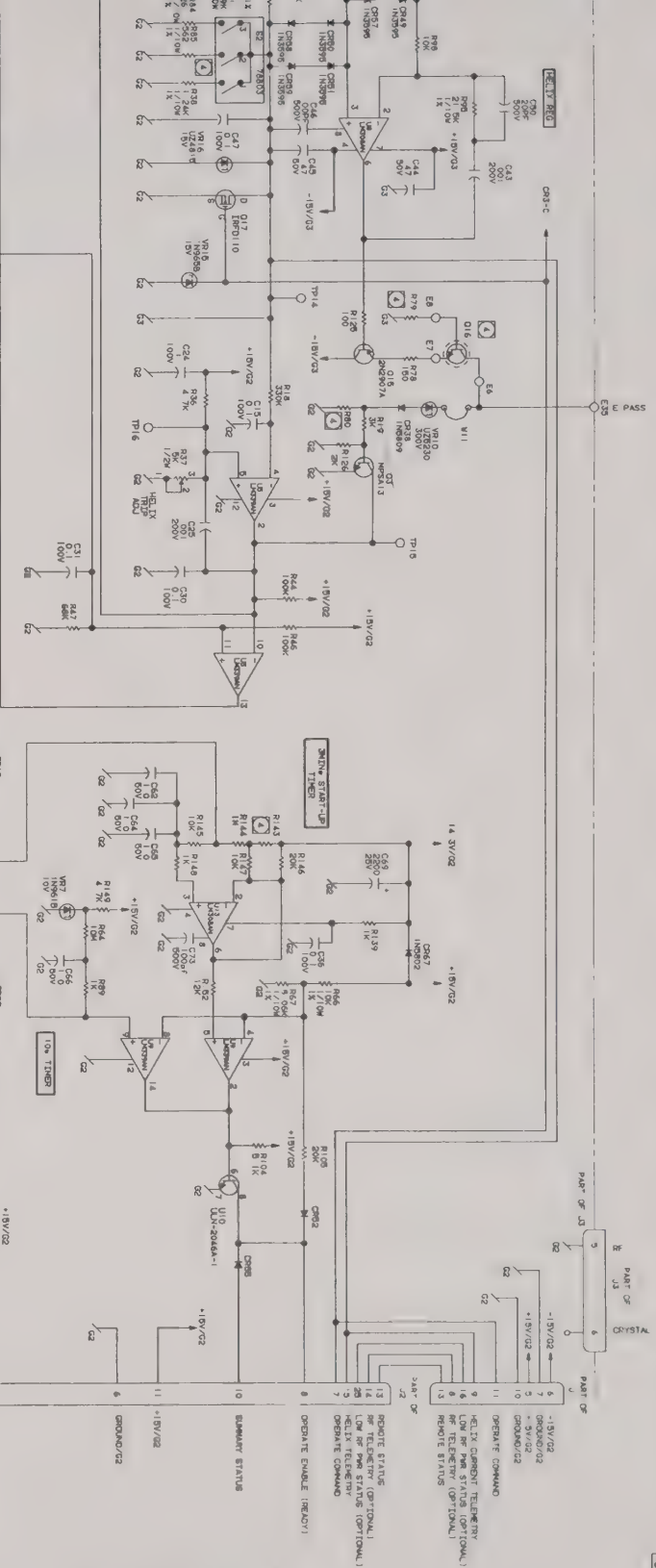
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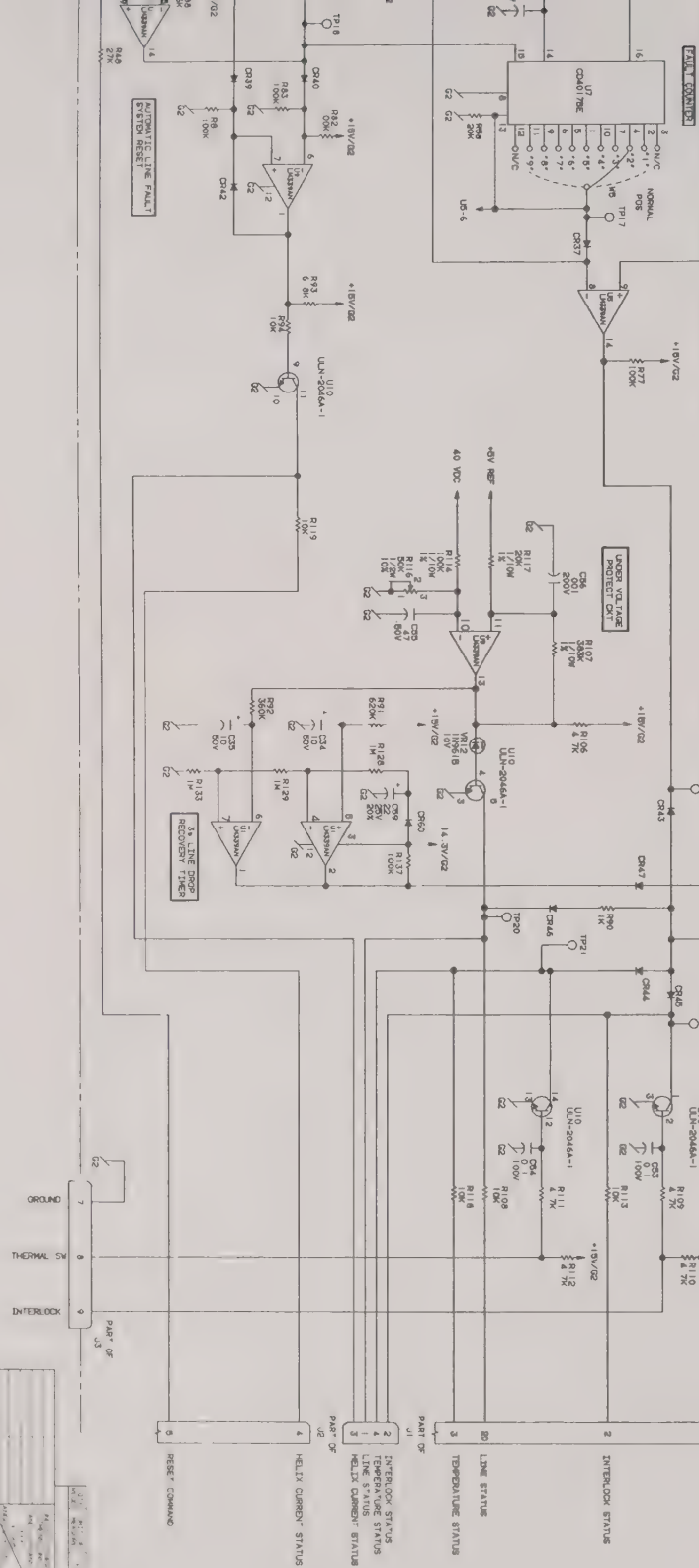
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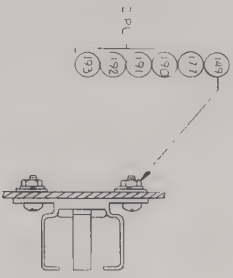
REPORTING DESIGNATIONS	
HIGH-LEVEL NO. USED	NUMBER NOT USED
8153	
U13	
CM7	
C73	
27	
1055	116, 9-22, 24, 25
73	
LC2	
K	
87	
52	
V1	14, 5, 8-10
1930	7924
636	614, 115, 201-24, 36, 38-40, 42-47
56	



CHB750466

8.0 ASSEMBLY DRAWINGS

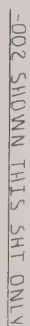
Document Number	Title
B737507	Display Board
B747180	High Voltage Board
B750466	Regulator Board
B724485	Remote Interface Board



- 3 CUT A 2 INSULATED WIRE (AWG 22) 1 STRIP BOTH ENDS
.25". FEED THRU T2 SOLDERING ONE WIRE TO E1 & E4
HOLES 1 SOLDERING 2ND WIRE TO E2 & E3 HOLES.

END 11000 REV JAN 80
DIETENCH+POST CLEARPRINT 3000H

SEE SEPARATE PARTS LIST PLB750466			
QTY	FSCH NO	PART NO OR IDENTIFYING NO	DESCRIPTION
		PARTS LIST	



RELEASE UNDER E.O. 14176

9.0 PARTS LIST

PARTS LIST / PART TRACEABILITY & QUALITY HISTORY CONTROL

LIST TITLE		DISPLAY BOARD ASSEMBLY		CONTRACT NO 8000H, 9000HA, 9075H, 9210HA		PLB737507																																
HUGHES HUGHES ELECTRONICS COMPANY		PREPARED BY C.M.FRANSSSEN		APPROVED BY J.PYTER		DATE 87-06-04																																
ELECTRON DYNAMICS DIVISION FOR THE ELECTRONIC INDUSTRIES, INCORPORATED, EL PASO, TEXAS		DATE 87-09-08		DATE 87-09-08		FSCM NO. 73293																																
		REV. LTR. B		SH 1 OF 5		DATE																																
REVISIONS																																						
EFF	AUTHORITY	LTR	DESCRIPTION			DATE	APPR																															
ALL UNITS CONFORM		A	COMPLETELY REVISED & REDRAWN ON CADAM.																																			
ALL UNITS CONFORM		B	ADDED FIND NO'S 41 & 43.			88-02-08	MSU																															
RELEASED ENGR. DOC. B 88-02-08 EP DOC. CONTROL CNTR. REV REL DATE BY																																						
SHEET	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
REV	B	A	A	B	A																																	

07

11

QTY REQD				FSCM	PART NO.	DESCRIPTION	REF DESIG	FIND NO
006	005	004	003					
		1	1		PWB737507-001	PWB, DISPLAY BD.	A7	1
								2
								3
		2	2		CKR06BX104KR	CAPACITOR, 0.1 μ f, 100V, 10%,	C1.2.	4
		1	1		CKR06BX104KR	CAPACITOR, 0.1 μ f, 100V, 10%,	C3.	5
		-	1		CKR06BX104KR	CAPACITOR, 0.1 μ f, 100V, 10%,	C4.	6
		1	1		CKR06BX104KR	CAPACITOR, 0.1 μ f, 100V, 10%,	C5.	7
		1	1		CKR05BX102KR	CAPACITOR, .001 μ f, 200V,	C6.	8
		5	5		CKR06BX104KR	CAPACITOR, 0.1 μ f, 100V, 10%,	C7-10. C13.	9
		2	2		CKR06BX105KR	CAPACITOR, 1 μ f, 50V,	C11,12.	10
								11
		1	1	51220	HDSP-4830	LED, BAR, RED,	DS1.	12
		-	1	51220	HDSP-4830	LED, BAR, RED,	DS2.	13
		4	4	51220	HLMP-2350	LED, RED,	DS3.5, 6,8.	14
		2	2	51220	HLMP-2500	LED, GREEN,	DS4.7.	15
		1	1	51220	HLMP-2300	LED, RED,	DS9.	16
								17
		1	1		RCR07G104JS	RESISTOR, 100K, 1/4W, 5%,	R1.	18
		1	1		RJR24FW502P	RESISTOR, ADJ, 5K, 1/2W, 10%,	R2.	19
		1	1		RCR07G122JS	RESISTOR, 1.2K, 1/4W, 5%,	R3.	20
		2	2		RCR42G390JS	RESISTOR, 39 Ω , 2W, 5%,	R4.5.	21
		2	2		RCR07G103JS	RESISTOR, 10K, 1/4W, 5%,	R6.7.	22

HUGHES HUGHES AIRCRAFT COMPANY		ELECTRON DYNAMICS DIVISION 10000 WILSON BLVD. WILSON, CALIF. 94094		SIZE CODE IDENT NO A 73293		PLB737507	
DATE OF ISSUE				REV A		SHEET 3 OF 5	

QTY REQD					FSCM	PART NO.	DESCRIPTION	REF DESIG	FIND NO
006	005	004	003	002					
		1	1	-		RCR07G304JS	RESISTOR, 300K, 1/4W, 5%,	R8,	23
		1	1	-		RJR24FW504P	RESISTOR, ADJ, 500K, 1/2W, 10%,	R9,	24
		-	1	-		RCR07G122JS	RESISTOR, 1.2K, 1/4W, 5%,	R10,	25
		-	1	-		RJR24FW502P	RESISTOR, ADJ, 5K, 1/2W, 10%,	R11,	26
		1	1	-		RJR24FW102P	RESISTOR, ADJ, 1K, 1/2W, 10%,	R12,	27
		-	2	-		RCR42G390JS	RESISTOR, 390, 2W, 5%,	R13, 14,	28
		4	4	4		RCR07G511JS	RESISTOR, 510, 1/4W, 5%,	R15, 17, 18, 20,	29
		2	2	2		RCR20G561JS	RESISTOR, 560, 1/2W, 5%,	R16, 21,	30
		1	1	1		RCR20G511JS	RESISTOR, 510, 1/2W, 5%,	R19,	31
		1	1	-		RJR24FW103P	RESISTOR, ADJ, 10K, 1/4W, 5%,	R22,	32
		2	2	-		RCR07G103JS	RESISTOR, 10K, 1/4W, 5%,	R23, 31,	33
		1	1	-		RCR07G515JS	RESISTOR, 5.1M, 1/4W, 5%,	R24,	34
		2	2	-		RCR07G102JS	RESISTOR, 1K, 1/4W, 5%,	R25, 28,	35
		1	1	-		RCR07G202JS	RESISTOR, 2K, 1/4W, 5%,	R26,	36
		1	1	-		RCR07G754JS	RESISTOR, 750K, 1/4W, 5%,	R27,	37
		2	2	-		RCR07G272JS	RESISTOR, 2.7K, 1/4W, 5%,	R29, 30,	38
		1	1	-		RCR07G183JS	RESISTOR, 18K, 1/4W, 5%,	R32,	39
		2	2	-		RCR32G151JS	RESISTOR, 150, 1W, 5%,	R33, 34,	40
		1	1	1		RCR07G202JS	RESISTOR, 2K, 1/4W, 5%,	R35,	41
									42
		3	3	3		1N4148	DIODE, 75V, 150mA,	CR1-CR3	43
									44

HUGHES ELECTRON DYNAMICS DIVISION
HUGHES AIRCRAFT COMPANY

DATE OF ISSUE

SIZE A CODE IDENT NO 73293

REV B SHEET 4 OF 5

PLB737507

QTY READ						FSCM	PART NO.	DESCRIPTION	REF DESIG	FINO NO	
006	005	004	003	002	001						
			1	1	1	27014	LM3914N	I.C. DISPLAY DRIVER, (18 PIN),	U1,	45	
			1	1	-	27014	LM358AN	I.C. OP AMP, (8 PIN),	U2,	46	
			-	1	-	27014	LM3915N	I.C.DISPLAY DRIVER, (18 PIN),	U3,	47	
										48	
			1	1	1		1N961B	DIODE, ZENER, 10V,	VR1,	49	
			1	1	-	12969	TVS318	DIODE, TRANSIENT SUPPRESSOR,	VR2,	50	
			2	2	-		UZ710	DIODE, ZENER, 10V,	VR3,4,	51	
										52	
			1	1	1	27264	22-11-2162	HEADER, 16PIN, .100SP,	J1,	53	
			1	1	-	27264	22-11-2022	HEADER, 2 PIN, .100SP,	J2,	54	
										55	
			1	1	1	55322	IC0-318-LGG	SOCKET, (U1),		56	
			1	1	-	55322	IC0-308-LGG	SOCKET, (U2),		57	
			-	1	-	55322	IC0-318-LGG	SOCKET, (U3),		58	
										59	
										60	
										61	
										62	
										63	
										64	
										65	
										66	
HUGHES HUGHES AIRCRAFT COMPANY ELECTRON DYNAMICS DIVISION 410 WEST LUTHER BLVD., TULSA, OKLAHOMA 74103						SIZE	CODE IDENT NO	PLB737507	REV A		SHEET 5 OF 5
						A	73293				
DATE OF ISSUE											

PARTS LIST / PART TRACEABILITY & QUALITY HISTORY CONTROL

LIST TITLE BOARD ASSY, HIGH VOLTAGE		CONTRACT NO 9075H04R200 8000H, 9000HA		PLB747180																																		
PREPARED BY R PERRY		APPROVED BY J PYTER	DATE 87-08-11	FSCM NO. 73293	SH <u>1</u> OF <u>5</u>																																	
DATE 87-08-06		APPROVED BY M VOLKOMENER	DATE 87-08-10	REV. LTR. <u>C</u>	DATE - -																																	
 HUGHES ELECTRON DYNAMICS DIVISION A DIVISION OF HUGHES AIRCRAFT COMPANY																																						
REVISIONS																																						
EFF	AUTHORITY	LTR	DESCRIPTION	DATE	APPR																																	
1ST USE/ N E		A	ON NOTE #1 ITEM #10 ASSY DASH NO. WAS -005.	87-09-16	J PYTER																																	
		B	F/N 32 WAS SIT, P/N WAS CMRIA902XXXX. SH2, NOTE 2: DELETE C9, W5	88-05-02	M.V.																																	
		C	F/N 39, P/N WAS UES1101.	87-03-10	<i>[Signature]</i>																																	
RELEASED ENGR. DOC. DOC. CONTROL CNTR. C REV 87-03-10 REL DATE E BY																																						
SHEET	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
REV	B	A	-	C	-																																	

PARTS LIST/PART TRACEABILITY AND QUALITY HISTORY CONTROL

STORE NO.	W.O.	END ITEM 8000H, 9000HA	ASSEMBLY DESCRIPTION BD ASSY, H.V.	ASSEMBLY NUMBER PLB747180	REV B	SERIAL NO.
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NOTES UNLESS OTHERWISE SPECIFIED:

1. USED ON:

TWT/TWTA APPLICATION				TWT/TWTA APPLICATION (CONT)			
NO.	TWT MODEL	TWTA MODEL	ASSY DASH NO.	NO.	TWT MODEL	TWTA MODEL	ASSY DASH NO.
1	911H	8001H11	-004	37			
2	991H	8010H11	-002	38	846H	8010H15	-003
3	912H	8001H12	-002	39			
4	992H	8010H12	-002	40	848HA	9020HA04	-003
5				41	848HB	9025HA04	-003
6				42	848HD	8010H04	-003
7	417HD	8010H09	-001	43			
8	418H	8020H09	-001	44	856H	8020H04	-003
9	419H	8020H10	-001	45			
10	564H	8010H01	-001	46			
11	568H	8020H01	-001	47	889H	8020H15	-003
12	568H-299	8010H19	-001	48			
13				49			
14				50			
15	640H	8020H02	-003	51	896H	9075H04	-006
16	646H	8010H13	-003	52			
17				53			
18				54			

2 USED ONLY ON UNITS REQUIRING IMPROVED SPURIOUS PERFORMANCE.

SH 2 OF 5

QTY RECD						FSCM	PART NO.	DESCRIPTION	REF DESIG	FIND NO
006	005	004	003	002	001					
1	1	1	1	1	1		PWB747180-001	PRINTED WIRING BD., H. V.		1
1	-	-	-	-	-		B732397-001	INSULATOR		2
										3
1	1	1	1	1	1		RCR07G100JS	RESISTOR, 10Ω, 1/4W, 5%	R8	4
1	1	1	1	1	1		RCR07G103JS	RESISTOR, 10K, 1/4W, 5%	R12	5
1	1	1	1	1	1		RCR07G104JS	RESISTOR, 100K, 1/4W, 5%	R9	6
1	1	1	1	1	1		RCR07G204JS	RESISTOR, 200K, 1/4W, 5%	R6	7
-	2	2	2	2	2		RCR20G102JS	RESISTOR, 1K, 1/2W, 5%	R4.5	8
3	-	-	-	-	-		RCR20G152JS	RESISTOR, 1.5K, 1/2W, 5%	R4.5. 7.	9
-	1	1	1	1	1		RCR20G152JS	RESISTOR, 1.5K, 1/2W, 5%	R7.	10
										11
										12
2	2	2	2	2	2		RCR42G510JS	RESISTOR, 51Ω, 2W, 5%	R1.10	13
-	2	2	2	-	2		RCR42G824JS	RESISTOR, 820K, 2W, 5%	R2.3	14
2	-	-	-	-	-	19647	MS310-1.82M, 1%	RESISTOR, 1.82M, 10W, 1%	R2.3	15
-	-	-	-	-	2	19647	MG721-4.00M, 1%	RESISTOR, 4.00M, 2W, 1%	R2.3	16
										17
1	1	1	1	1	1	19647	MG750-50M, 1%	RESISTOR, 50M, 5W, 1%	R11	18
										19
										20
										21
										22
HUGHES ELECTRON DYNAMICS DIVISION HUGHES AIRCRAFT COMPANY DATE OF ISSUE							SIZE	CODE	IDENT NO	PLB747180
							A	73293	REV -	SHEET 3 OF 5

006	QTY REQD						FSCM	PART NO.	DESCRIPTION	REF DESIG	FIND NO
	005	004	003	002	001	000					
-	2	2	2	2	2	2	23280	KMR1A4578SP-1	CAPACITOR, .03μF, 8.3KV	C3.7	23
2	-	-	-	-	-	-	23280	KMR1A4635SP-1	CAPACITOR, .03μF, 10.7KV	C3.7	24
2	2	-	2	-	2	2	23280	KMR1A4578SP-2	CAPACITOR, .2μF, 3KV	C1.2	25
-	2	-	2	-	2	2	23280	KMR1A4578SP-3	CAPACITOR, .02μF, 3KV	C4.5	26
-	-	4	-	4	-	-	23280	KMR1A4578SP-3	CAPACITOR, .02μF, 3KV	C1.2, C4.5	27
2	-	-	-	-	-	-	23280	KMR1A4635SP-2	CAPACITOR, .02μF, 3.3KV	C4.5	28
-	1	1	1	1	1	1	23280	KMR1A4578SP-4	CAPACITOR, .001μF, 8.3KV	C8	29
1	-	-	-	-	-	-	23280	KMR1A4635SP-3	CAPACITOR, .001μF, 10.7KV	C8	30
											31
A/R	A/R	A/R	A/R	A/R	A/R	A/R	23280	CMR1A902161K	CAPACITOR, 160pf, 9KV	C9	32
											33
1	1	1	1	1	1	1	67640	SMC-50VB10	CAPACITOR, 10μF, 50V, ±20%	C6	34
											35
											36
-	16	16	16	16	16	16	30043	SHE-25F	DIODE, 2.5KV, 200nS, 1A	CR1-16	37
16	-	-	-	-	-	-	30043	SHE-40F	DIODE, 4KV, 200nS, 1A	CR1-16	38
2	2	2	2	2	2	2		IN5802	DIODE, 50V, 25nS, 2.5A	CR17, 18	39
1	1	1	1	1	1	1		IN4148	DIODE, 75V, 200mA	CR19	40
											41
1	1	1	1	1	1	1	12969	UZ4851	DIODE, ZENER, 51V, 5%	VR1	42
											43
											44

HUGHES ELECTRON DYNAMICS DIVISION HUGHES AIRCRAFT COMPANY		SIZE A	CODE 73293	IDENT NO PLB747180
DATE OF ISSUE		REV	C	SHEET 4 OF 5

QTY READ						FSCM	PART NO.	DESCRIPTION	REF DESIG	FIND NO
006	005	004	003	002	001					
1	1	1	1	1	1		2N2907A	TRANSISTOR	01	45
1	1	1	1	1	1	01295	TIP30A	TRANSISTOR	02	46
										47
1	1	1	1	1	1	30161	5968B	HEATSINK (Q2)		48
										49
										50
-	-	-	-	-	A/R	70903	8021-100	WIRE BUS, 22AWG	W1	51
A/R	-	A/R	A/R	A/R	-	70903	8021-100	WIRE BUS, 22AWG	W2	52
-	A/R	-	-	-	-		B185055-005	WIRE, HV, CR, 24AWG, YEL	W3, 4, 6	53
A/R	-	A/R	A/R	A/R	A/R		B185055-005	WIRE, HV, CR, 24AWG, YEL	W4, 6	54
A/R	A/R	A/R	A/R	A/R	A/R		B185055-005	WIRE, HV, CR, 24AWG, YEL	W5	55
									(2)	56
										57
										58
										59
										60
										61
										62
										63
										64
										65
										66
HUGHES ELECTRON DYNAMICS DIVISION HUGHES AIRCRAFT COMPANY						SIZE A		CODE IDENT NO 73293	PLB747180	
						DATE OF ISSUE		REV -	SHEET 5 OF 5	

PARTS LIST / PART TRACEABILITY & QUALITY HISTORY CONTROL

LIST TITLE REGULATOR BD. ASSY.		CONTRACT NO. 8000H, 9000HA		PLB750466	
PREPARED BY C. FRANSSÉN		APPROVED BY A. MILOUD	DATE 89-03-13	FSCM NO. 73293	SH 1 OF 16
DATE 89-03-13		APPROVED BY B. BEHLER	DATE 89-03-15	REV. LTR. A	DATE
HUGHES HUGHES AIRCRAFT COMPANY ELECTRON DYNAMICS DIVISION FOR PARTS LIST ONLY - NOT FOR ENGINEERING OR DESIGN PURPOSES					
REVISIONS					
EFF	AUTHORITY	LTR	DESCRIPTION	DATE	APPR
		A	SH. 2: ADDED NOTE 8. SH. 4: R99 FOR TWT 912H WAS RNC55H5232FS. SH. 5 & 6: R8 WAS 1.5K FOR TWT 417H - 889H. R8 WAS 5.1K FOR TWT 911H - 992H. SH. 6: R100 P/N FOR 912H TWT WAS RJR24FW203P. F/N 3: P/N WAS 818-000-Z5U0-103M. F/N 6: QTY WAS 16. F/N 49: DELETED 110. 111, FROM REF DES BLOCK. F/N 141: QTY WAS 41. DELETED F/N 154. ADDED F/N 179. F/N 181 P/N WAS RC-T05038-2A. F/N 183 P/N WAS 8021-100, ADDED NOTE 8.	3-30-89 <i>AM</i>	<i>CMF</i>
RELEASED ENGR. DOC. DOC. CONTROL CNTR. A 89-03-30 REV REL DATE VPD BY					

SHEET	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
REV	A	A	-	A	A	A	A	-	A	-	-	-	A	A	A	A	A																					

PARTS LIST/PART TRACEABILITY AND QUALITY HISTORY CONTROL

STORE NO.	W.O.	END ITEM	ASSEMBLY DESCRIPTION	ASSEMBLY NUMBER	REV	SERIAL NO.
		8000H, 9000HA	REG. BD. ASSY.	PLB750466	A	

NOTES UNLESS OTHERWISE SPECIFIED:

1. ALTERNATE PARTS MAY BE USED.
2. 0-225V RANGE POSITION SI AS SHOWN.  (UP)  (DOWN)
3. 225-450V RANGE POSITION SI AS SHOWN. _____
4. S2 CONFIGURATION
5. NOMINAL VALUE FOR R10 IS SHOWN. VALUE OF R10 MAY BE ADJUSTED TO ACHIEVE SPECIFIED PULSE RATE.
6. DO NOT USE MOTOROLA PARTS IN THIS APPLICATION.
AFTER FINAL TEST STAKE ACTUATORS ON ALL ADJUSTABLE COMPONENTS USING GLYPTOL. CARE MUST BE EXERCISED TO ENSURE THAT GLYPTOL DOES NOT ENTER THE COMPONENTS AND IMPAIR THEIR PERFORMANCE.
7. USE HEATSINK P/N 2211B, FSCM 30161, WITH TRANSISTOR P/N 2N3439. ASSEMBLE HEATSINK USING THREAD LOCKING COMPOUND.
8. USE F/N 183 TO MAKE CONNECTION BETWEEN E2 & E3, AND E4 & E1.

SH 2 OF 16

TWT SIT CONFIGURATION TABLE

PRIMARY REG		HELIX REGULATOR					
TWT	L2	U12	Q16 ASSY	R79	R80	R99	
417HD	B737639-001	B750468-001	B724520-001	RCR07G681JS	RCR07G100JS	RNC55H1543FS	
418H	B737639-001	B750468-001	B724520-001	RCR07G681JS	RCR07G100JS	RNC55H1543FS	
419H	B737639-001	B750468-001	B724520-001	RCR07G681JS	RCR07G100JS	RNC55H1543FS	
564H	B704107-001	B750468-001	B724520-001	RCR07G681JS	RCR07G5R1JS	RNC55H1543FS	
568H-299	B737639-001	B750468-001	B724520-001	RCR07G681JS	RCR07G100JS	RNC55H1543FS	
568H	B737639-001	B750468-001	B724520-001	RCR07G681JS	RCR07G100JS	RNC55H1543FS	
640H	B737639-001	B750468-002	2N3439	RCR07G102JS	RCR07G100JS	RNC55H8872FS	
646H	B704107-001	B750468-002	2N3439	RCR07G102JS	RCR07G100JS	RNC55H1003FS	
648HD	B704107-001	B750468-002	2N3439	RCR07G102JS	RCR07G100JS	RNC55H1003FS	
648HDS	B704107-001	B750468-002	2N3439	RCR07G102JS	RCR07G100JS	RNC55H1003FS	
664H	B704107-001	B750468-002	2N3439	RCR07G102JS	RCR07G100JS	RNC55H8872FS	
670HA	B737639-001	B750468-002	2N3439	RCR07G102JS	RCR07G100JS	RNC55H8872FS	
670HA-299	B737639-001	B750468-002	2N3439	RCR07G102JS	RCR07G100JS	RNC55H8872FS	
771HD	B704107-001	B750468-002	2N3439	RCR07G102JS	RCR07G100JS	RNC55H7682FS	
771HDS	B704107-001	B750468-002	2N3439	RCR07G102JS	RCR07G100JS	RNC55H7682FS	
783H	B704107-001	B750468-002	2N3439	RCR07G102JS	RCR07G100JS	RNC55H7682FS	
785HD	B704107-001	B750468-002	2N3439	RCR07G102JS	RCR07G100JS	RNC55H7682FS	
846H	B704107-001	B750468-002	2N3439	RCR07G102JS	RCR07G100JS	RNC55H7682FS	
848HA	B704107-001	B750468-002	2N3439	RCR07G102JS	RCR07G100JS	RNC55H8452FS	
848HB	B704107-001	B750468-002	2N3439	RCR07G102JS	RCR07G100JS	RNC55H7682FS	
HUGHES ELECTRON DYNAMICS DIVISION HUGHES AIRCRAFT COMPANY				SIZE A	CODE IDENT NO 73293	PLB750466	
DATE OF ISSUE				REV -	SHEET 3 OF 16		

TWT SIT CONFIGURATION TABLE

TWT	HELIX REG	S2		3	ANODE SUPPLY	MAIN CONV.	TIMER
		I _w SCALE	POSITION				
	R100				SI	R8	R143
417HD	RJR24FW104P	20mA	1-OFF 2-OFF 3-ON			RCR07G152JS	RNC55H1004FS
418H	RJR24FW104P	20mA	1-OFF 2-OFF 3-ON			RCR07G152JS	RNC55H1004FS
419H	RJR24FW104P	20mA	1-OFF 2-OFF 3-ON			RCR07G152JS	RNC55H1004FS
564H	RJR24FW104P	20mA	1-OFF 2-OFF 3-ON			RCR07G152JS	RNC55H1004FS
568H-299	RJR24FW104P	20mA	1-OFF 2-OFF 3-ON			RCR07G152JS	RNC55H1004FS
568H	RJR24FW104P	20mA	1-OFF 2-OFF 3-ON			RCR07G152JS	RNC55H1004FS
640H	RJR24FW253P	5 mA	1-ON 2-OFF 3-OFF			RCR07G152JS	RNC55H1004FS
646H	RJR24FW503P	5 mA	1-ON 2-OFF 3-OFF			RCR07G152JS	RNC55H1004FS
648HD	RJR24FW503P	5 mA	1-ON 2-OFF 3-OFF			RCR07G152JS	RNC55H1004FS
648HDS	RJR24FW503P	5 mA	1-ON 2-OFF 3-OFF			RCR07G152JS	RNC55H1004FS
664H	RJR24FW253P	5 mA	1-ON 2-OFF 3-OFF			RCR07G152JS	RNC55H1004FS
670HA	RJR24FW253P	10mA	1-OFF 2-ON 3-OFF			RCR07G152JS	RNC55H1004FS
670HA-299	RJR24FW253P	10mA	1-OFF 2-ON 3-OFF			RCR07G152JS	RNC55H1004FS
771HD	RJR24FW253P	5 mA	1-ON 2-OFF 3-OFF			RCR07G152JS	RNC55H1004FS
771HDS	RJR24FW253P	5 mA	1-ON 2-OFF 3-OFF			RCR07G152JS	RNC55H1004FS
783H	RJR24FW253P	5 mA	1-ON 2-OFF 3-OFF			RCR07G152JS	RNC55H1004FS
785HD	RJR24FW253P	5 mA	1-ON 2-OFF 3-OFF			RCR07G152JS	RNC55H1004FS
846H	RJR24FW253P	5 mA	1-ON 2-OFF 3-OFF			RCR07G152JS	RNC55H1004FS
848HA	RJR24FW253P	5 mA	1-ON 2-OFF 3-OFF			RCR07G152JS	RNC55H1004FS
848HB	RJR24FW253P	5 mA	1-ON 2-OFF 3-OFF			RCR07G152JS	RNC55H1004FS

2

HUGHES HUGHES AIRCRAFT COMPANY ELECTRON DYNAMICS DIVISION 10000 WILLOW CREEK, CANTON, OHIO 44705-4091		SIZE A	CODE IDENT NO 73293	PLB750466
DATE OF ISSUE		REV A	SHEET 5 OF 16	

QTY REQD		FSCM	PART NO.	DESCRIPTION	REF. FIND DESIG. NO
REV	-001				
	1		PWB750466-001	PWB, REGULATOR BOARD,	1
					2
A	2	15450	DD16F10Y5P103K1KV	CAPACITOR, .01 μ F, 1000V,	C6.21, 3
	2		CKR06BX223KR	CAPACITOR, .022 μ F, 100V,	C1.8, 4
	4	67640	SMC50VB100M5X11	CAPACITOR, 10 μ F, 50V, 20%,	C2.18, 34.36, 5
A	15		CKR06BX104KR	CAPACITOR, 0.1 μ F, 100V, 10%,	C3.11, 15, 19.20, 24, 30.31, 36, 41.47, 58, 64.67, 68, 6
	4		CKR06BX103KR	CAPACITOR, .01 μ F, 200V, 10%,	C5.23, 29.42, 7
	2	67640	RXC100VB22RW12X24	CAPACITOR, 22 μ F, 100V, 10%,	C7.22, 8
	2	67640	SMC50VB220M6X11	CAPACITOR, 22 μ F, 50V, 20%,	C9.39, 9
	1	67640	LX250VB10RM12X25LLV	CAPACITOR, 10 μ F, 250V	C70, 10
	1		CKR06BX562KR	CAPACITOR, .0056 μ F, 200V,	C12, 11
	1		CKR05BX471KR	CAPACITOR, 470pF, 200V,	C27, 12
					13
	3		CMR06F471J0DP	CAPACITOR, 470pF, 500V,	C10.32, 37, 14
	1	56289	80D681P080HB5	CAPACITOR, 680 μ F, 80V,	C13, 15
	1		CKR06BX472KR	CAPACITOR, .0047 μ F, 200V, 10%,	C14, 16
	2	56289	80D102P200ME5	CAPACITOR, 1000 μ F, 200V,	C16.17, 17
	5		CKR05BX102KR	CAPACITOR, .001 μ F, 200V, 10%,	C4.25, 43, 51.56, 18
					19
					20
					21

HUGHES ELECTRON DYNAMICS DIVISION HUGHES AIRCRAFT COMPANY		SIZE A	CODE 73293	IDENT NO PLB750466
DATE OF ISSUE		REV	A	SHEET 7 OF 16

REV	QTY REQD		FSCM	PART NO.	DESCRIPTION	REF DESIG	FIND NO
		001					
		3		CMR04F101J0DP	CAPACITOR, 100pF, 500V,	C33.46.73	22
							23
							24
							25
							26
		1		CMR07F153J0DP	CAPACITOR, .015μF, 500V,	C71.	27
		2		CKR06BX334KR	CAPACITOR, .33μF, 50V, 10%,	C28.63.	28
							29
							30
		5		CKR06BX105KR	CAPACITOR, 1.0μF, 50V, 10%,	C62.64.66. 72.	31
		1		CMR04F200J0DP	CAPACITOR, 20pF, 500V,	C80.	32
		2		CKR06BX473KR	CAPACITOR, .047μF, 100V, 10%,	C82.67.	33
		6		CKR06BX474KR	CAPACITOR, .47μF, 50V, 10%,	C26.74.48. 55.61.68.	34
		2	09023	MMWA6P47K	CAPACITOR, .47μF, 600V, 10%,	C40.49.	35
		1	09023	WMF6S47K	CAPACITOR, .047μF, 600V, 10%,	C60.	36
							37
		1	67640	SMC25VB222M16X35	CAPACITOR, 2200μF, 25V, 20%,	C69.	38
							39
		2	67640	SMC25VB220M5X11	CAPACITOR, 22μF, 25V, 20%,	C18.59.	40
							41
							42
							43

HUGHES ELECTRON DYNAMICS DIVISION HUGHES AIRCRAFT COMPANY		SIZE A	CODE IDENT NO 73293	PLB750466
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REV	QTY	RECD	FSCM	PART NO.	DESCRIPTION	REF DESIG	FIND NO
		-001					44
							45
							46
	8			RCR07G102JS	RESISTOR, 1K, 1/4W, 5%,	R3.42.43. 89.90. 103.139, 148.	47
	20			RCR07G103JS	RESISTOR, 10K, 1/4W, 5%,	R2.4-6. 30.32.50. 54.70.94. 96.102. 108.113. 118.119. 123.124. 145.147. R36.106. 109-112. 141.142. 149.	48
A	9			RCR07G472JS	RESISTOR, 4.7K, 1/4W, 5%,		49
	1			RCR42G101JS	RESISTOR, 100Ω, 2W, 5%,	R9.	50
	1			RNC55H200IFS	RESISTOR, 2K, 1/10W, 1%,	R10. 4	51
	1			RNC55H8252FS	RESISTOR, 82.5K, 1/10W, 1%,	R11.	52
3				RNC55H1003FS	RESISTOR, 100K, 1/10W, 1%,	R13.14. 114.	53
1				RNC55H4992FS	RESISTOR, 49.9K, 1/10W, 1%,	R15.	54
1				RNC55H150IFS	RESISTOR, 1.5K, 1/10W, 1%,	R16.	55
1				RNC55H523IFS	RESISTOR, 5.23K, 1/10W, 1%,	R7.	56
							57
							58
1				RJR24FW102P	RESISTOR, ADJ, 1K, 1/2W, 10%,	R17.	59
1				RCR07G334JS	RESISTOR, 330K, 1/4W, 5%,	R18.	60
1				RCR32G821JS	RESISTOR, 820Ω, 1W, 5%,	R20.	61
1				RCR07G123JS	RESISTOR, 12K, 1/4W, 5%,	R152.	62
HUGHES ELECTRON DYNAMICS DIVISION HUGHES AIRCRAFT COMPANY					SIZE A	CODE IDENT NO 73293	PLB750466
DATE OF ISSUE					REV	A	SHEET 9 OF 16

REV	QTY REQD		FSCM	PART NO.	DESCRIPTION	REF DESIG	FIND NO
		-001					
		1		RNC55H1621FS	RESISTOR, 1.62K, 1/10W, 1%,	R61.	63
		2		RCR42G683JS	RESISTOR, 68K, 2W, 5%,	R22.23.	64
		2		RCR20G511JS	RESISTOR, 510Ω, 1/2W, 5%,	R24.27.	65
							66
		1		RCR07G302JS	RESISTOR, 3K, 1/4W, 5%,	R19.	67
		1		RCR07G273JS	RESISTOR, 27K, 1/4W, 5%,	R48.	68
		6		RCR07G203JS	RESISTOR, 20K, 1/4W, 5%,	R28.31.56. 58.105. 146.	69
		1		RCR07G682JS	RESISTOR, 6.8K, 1/4W, 5%,	R93.	70
		1		RNC55H2002FS	RESISTOR, 20K, 1/10W, 1%,	R117.	71
		1		RCR07G100JS	RESISTOR, 100, 1/4W, 5%,	R160.	72
							73
							74
		1		RJR24FW502P	RESISTOR, ADJ, 5K, 1/2W, 10%,	R37.	75
							76
		3		RCR07G151JS	RESISTOR, 150Ω, 1/4W, 5%,	R26.26.78.	77
		3		RCR07G202JS	RESISTOR, 2K, 1/4W, 5%,	R1.21. 126.	78
		2		RCR07G122JS	RESISTOR, 1.2K, 1/4W, 5%,	R82.83.	79
							80
		1		RNC55H2152FS	RESISTOR, 21.5K, 1/10W, 1%,	R95	81
		12		RCR07G104JS	RESISTOR, 100K, 1/4W, 5%,	R44.46.67. 72.77.81. 82.83.86. 87.97.137.	82
		1		RCR07G473JS	RESISTOR, 47K, 1/4W, 5%,	R45.	83

HUGHES
HUGHES AIRCRAFT COMPANY

ELECTRON DYNAMICS DIVISION
THE WEST LUTHER BULLINGTON WORKS, CAMBRIDGE, MASS.

PLB750466

SIZE
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REV

-

SHEET

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REV	QTY REQD	FSCM	PART NO.	DESCRIPTION	REF DESIG NO	FIND NO
	1-001					
			RCR07G683JS	RESISTOR, 68K, 1/4W, 5%,	R47.	84
			RCR07G622JS	RESISTOR, 6.2K, 1/4W, 5%,	R55.	85
			RNC55H2610FS	RESISTOR, 2610, 1/10W, 1%	R84.	86
			RNC55H3012FS	RESISTOR, 30.1K, 1/10W, 1%,	R59.	87
	2		RCR42G470JS	RESISTOR, 470, 2W, 5%,	R131, 132.	88
			RCR07G563JS	RESISTOR, 56K, 1/4W, 5%,	R88.	89
			RJR24FW202P	RESISTOR, ADJ, 2K, 1/2W, 10%,	R62.	90
			RCR07G624JS	RESISTOR, 620K, 1/4W, 5%,	R91.	91
			RNC55H1692FS	RESISTOR, 16.9K, 1/10W, 1%,	R65.	92
	4		RCR07G101JS	RESISTOR, 1000, 1/4W, 5%,	R35, 39, 121, 125.	93
			RCR42G202JS	RESISTOR, 2K, 2W, 5%,	R69.	94
			RJR24FW105P	RESISTOR, ADJ, 1M, 1/2W, 10%,	R71.	95
			RCR07G304JS	RESISTOR, 300K, 1/4W, 5%,	R73.	96
			RCR20G105JS	RESISTOR, 1M, 1/2W, 5%,	R74.	97
			RCR07G751JS	RESISTOR, 7500, 1/4W, 5%,	R75.	98
			RCR07G364JS	RESISTOR, 360K, 1/4W, 5%,	R92.	99
	5		RCR07G105JS	RESISTOR, 1M, 1/4W, 5%,	R128, 129, 133, 140, 144.	100
	3		RNC55H1002FS	RESISTOR, 10K, 1/10W, 1%,	R33, 40. 66.	101
			RNC55H1241FS	RESISTOR, 1.24K, 1/10W, 1%,	R38.	102
			RNC55H5620FS	RESISTOR, 5620, 1/10W, 1%,	R80.	103
			RCR42G203JS	RESISTOR, 20K, 2W, 5%,	R136.	104
			RNC55H8061FS	RESISTOR, 8.06K, 1/10W, 1%,	R67.	105
HUGHES ELECTRON DYNAMICS DIVISION HUGHES AIRCRAFT COMPANY				SIZE A	CODE IDENT NO 73293	PLB750466
DATE OF ISSUE				REV -	SHEET 11 OF 16	

REV	QTY	REQD	FSCM	PART NO.	DESCRIPTION	REF DESIG	FIND NO
001						R134, 135.	106
2				RCR42G390JS	RESISTOR, 390, 2W, 5%.		
1				RCR07G7R5JS	RESISTOR, 7.50, 1/4W, 5%.	R153.	107
							108
1				RCR07G106JS	RESISTOR, 10M, 1/4W, 5%.	R64.	109
1				RWP81S1R50FR	RESISTOR, 1.50, 1W, 1%.	R96.	110
1				RCR07G242JS	RESISTOR, 2.4K, 1/4W, 5%	R34.	111
2				RCR20G242JS	RESISTOR, 2.4K, 1/2W, 5%.	R76, 127.	112
1				RNC55H4991FS	RESISTOR, 4.99K, 1/10W, 1%.	R101.	113
1				RJR24FW503P	RESISTOR, ADJ, 50K, 1/2W, 10%.	R116.	114
1				RNC55H3833FS	RESISTOR, 383K, 1/10W, 1%.	R107.	115
12				RCR07G512JS	RESISTOR, 5.1K, 1/4W, 5%.	R9, 12, 27. 40, 50, 60, 68, 82. 104, 122. 181.	116
2				RCR07G152JS	RESISTOR, 1.5K, 1/4W, 5%.	R118, 120.	117
2				RCR20G100JS	RESISTOR, 100, 1/2W, 5%.	R130, 136.	118
3				2N2222A	TRANSISTOR, 75V, 6A.	01, 7, 13.	119
2				2N2907A	TRANSISTOR, 60V, 5A.	02, 15.	120
2				2N3019	TRANSISTOR, 80V, 1A.	05, 6.	121
2				IRF512	TRANSISTOR, 100V, 2.5A.	09, 10.	122
1				2N3439	TRANSISTOR, 350V, 1A.	014.	123
1				IRFD110	TRANSISTOR, 100V, 1A.	017.	124
1				MPSA13	TRANSISTOR, 100V, 1A.	03.	125
4				IRF842	TRANSISTOR, 500V, 7A	04, 8, 11. 12.	126

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REV	QTY		FSCM	PART NO.	DESCRIPTION	REF. FIND DESIGN NO.
	REQD	ISSUED				
		1		IN748A	DIODE, ZENER, 3.9V,	VR1, 127
		4		IN961B	DIODE, ZENER, 10V,	VR4, 7.8, 12, 128
		3	12969	UZ4836	DIODE, ZENER, 36V,	VR2, 17.18, 129
		1	12969	UZ4815	DIODE, ZENER, 15V,	VR16, 130
		3	12969	UZ4851	DIODE, ZENER, 51V,	VR3, 5.6, 131
		1	12969	UZ5230	DIODE, ZENER, 300V,	VR10, 132
		2	12969	UZ5140	DIODE, ZENER, 400V,	VR23, 26, 133
		1	95051	LM329BZ	DIODE, PREC REF, 6.9V,	VR11, 134
		1		IN751A	DIODE, ZENER, 5.1V,	VR13, 135
		1		IN965B	DIODE, ZENER, 15V,	VR15, 136
						137
						138
		1	12969	UES1306	DIODE, 400V, 5A, 50ns,	CR84, 139
		4		IN6045A	DIODE, 17.1-18.9V,	CR63-66, 140
A		37		IN4148	DIODE, 75V, 150mA	CR13, 8, 10-13, 16, 17, 18, 19, 25, 27, 33, 47, 52, 53, 55, 60, 141
		5		IN5809	DIODE, 100V, 6A,	CR4-7, 38, 142
		3		IN4948	DIODE, 1KV, 1A, 200ns,	CR31, 32, 36, 143
		10		IN3595	DIODE, 150V, 150mA,	CR2, 9, 48- 51, 56-59, 144
		5		IN5802	DIODE, 50V, 2.5A,	CR14, 15, 28, 29, 67, 145
		2	12969	IN4247	DIODE, 600V, 1A,	CR61, 62, 146
HUGHES ELECTRON DYNAMICS DIVISION HUGHES AIRCRAFT COMPANY DATE OF ISSUE						SIZE A CODE IDENT NO 73293 REV A SHEET 13 OF 16

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REV	QTY	RECD	FSCM	PART NO.	DESCRIPTION	REF DESIG	FIND NO
		-001					147
	2		34333	SG1524BJ	I.C., PWM,	U2.3,	148
	1		12969	PIC600	I.C., PWR HYBRID, 60V, 5A,	U4,	149
	3		95051	LM339AN	I.C., QUAD COMPARTOR,	U1.5.9,	150
	3		95051	LM308AN	I.C. OP AMP,	U6.8.13,	151
	1		18714	CD4017BE	I.C., COUNTER	U7,	152
	1		04713	4N24	I.C., OPTOCOUPLER,	U11,	153
A	1			B750468-	COMPONENT ASSY, SII	U12	154
	1		56289	ULN2046A-1	TRANSISTOR ARRAY,	U16,	155
	1		01833	CL60	THERMISTOR, 100,	R11,	156
	1		99208	HE421C2490	RELAY,	K1,	157
	1			B711498-001	TRANSFORMER, DRIVE,	Y1,	158
	1			B750489-001	TRANSFORMER, BIAS,	Y3,	159
							160
	1		02113	D1869	TRANSFORMER,	T2,	161
	1			B704153-001	INDUCTOR, 720uH,	L1,	162
							163
							164
	3		55322	IC0-308-SGG	SOCKET, I.C., 8 PIN	X06.8.13	165
	4		55322	IC0-314-SGG	SOCKET, I.C., 14PIN	X01.5.9, 10,	166
	4		55322	IC0-316-SGG	SOCKET, I.C., 16PIN	X02.3.7, 12	167
	2		55322	SL-102-G-11	SOCKET STRIP	X017	168

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HUGHES ELECTRON DYNAMICS DIVISION
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DATE OF ISSUE

REV		QTY		REDD		FSCM	PART NO.	DESCRIPTION	REF DESIG	FIND NO
					-0011					
										169
										170
										171
										172
										173
										174
										175
					2	30161	5968B	HEATSINK, (09,10),		176
					1	30161	5792B	HEATSINK, (U4),		177
					1	30161	2211B	HEATSINK, (016)		178
A					4	30161	60130-020-PB	HEATSINK, (04,8,11,12)		179
										180
A					1	IV040	602-038	INSULATOR, .200 DIA., UNIVERSAL	(011)	181
					1					182
A					AR		NAS-703-22UC-2	WIRE, INSULATED, 22 AWG	8	183
					AR	92194	TFT-250	SLEEVING, TEFLON,	(0963-66)	184
										185
										186
										187
										188
										189
					6		MS35338-135	WASHER-SPLIT, #4-40,		190

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REV A

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HUGHES ELECTRON DYNAMICS DIVISION

HUGHES AIRCRAFT COMPANY

DATE OF ISSUE

REV	QTY	READ	FSCM	PART NO.	DESCRIPTION	REF DESIG	FIND NO
		-001					
		6		MS15795-803	WASHER, FLAT, #4-40,		191
A		6		MS35649-244	NUT, #4,		192
		6		MS51957-14	SCREW, PAN HD, #4-40 X 5/16 LG,		193
		1	27264	09-72-2091	HEADER, 9 PIN,	J8,	194
		2	27264	09-72-2061	HEADER, 6 PIN,	J4, 6,	195
		1	27264	09-72-2041	HEADER, 4 PIN,	J5,	196
		1	06383	MLSS-100-16-B	HEADER, 16PIN,	J1,	197
		1	06383	MLSS-100-25-B	HEADER, 25PIN,	J2,	198
							199
							200
							201
		1	81073	78J01	DIP SWITCH, SPDT,	J1, 2	202
		1	81073	78B03	DIP SWITCH, 3PDT,	J2, 3	203
							204
							205
							206
							207
							208
							209
							210
							211
							212

HUGHES ELECTRON DYNAMICS DIVISION HUGHES AIRCRAFT COMPANY		SIZE A	CODE IDENT NO 73293	PLB750466
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[illegible]

NOTES: UNLESS OTHERWISE SPECIFIED

1. -001 REMOTE INTERFACE BOARD
 -002 REMOTE BEAM CONTROL (R012)
 -003 REMOTE INTERFACE, RCU CONTROL
 -004 REMOTE INTERFACE T.I. (OS8/064)

2. PWB 724485-002 THRU-004 ARE MODIFIED BDS. MADE FROM PWB 742485-001.

HUGHES ELECTRON DYNAMICS DIVISION
22240 Vanowen Street, Torrance, California 90505

FSCM NO.
73293

NO. **PLB724485**

REV **C**

SHEET **Z OF 5**

QTY REQD				FSCM	PART NO.	DESCRIPTION	REF DESIG NO	FIND NO
001	002	003	004					
3	3	-	3		CK06BX104K	CAPACITOR, .1uF, 100V	C1-3	14
-	-	1	-				C3	15
2	-	2	2		IN400Z	DIODE, 1A, 100V	CR1,2	16
-	3	-	-				CR1-3	17
4	4	-	4		TVS 315	SUPPRESSOR, TRANSIENT, 15V	VR1,2,4,5	18
-	-	1	-		12969		VR1	19
1	1	1	1		IN965B	DIODE, ZENER, 15V	VR3	20
1	1	1	1		MC1416P	IC, DRIVER ARRAY	U1	21
1	1	1	1		CD4069UBE	CMOS HEX INVERTER	U2	22
1	1	1	1		LM324AN	IC, OPERATIONAL AMPLIFIER	U3	23
2	2	2	2		T90NID1212	RELAY, 1 FORM A, 12V	K1,2	24
1	-	-	1				K3	25
-	2	-	-		190-22B100	RELAY, 2 FORM C, 12V	K3,4	26
-	-	-	-		04221			27
-	-	1	-		05292	RELAY, 2 FORM C, 24V	K3	28
-	-	-	-					29
-	-	-	-					30

HUGHES
HUGHES AIRCRAFT COMPANY

ELECTRON DYNAMICS DIVISION
3100 West Loma Boulevard Torrance, California 90508

PLB724485
REV C
SHEET 4 OF 5

QTY REQD				FSCM	PART NO.	DESCRIPTION	REF DESIG	FIND NO	
	2004	003	002						001
	2	2	2	2	55322	ICD-31A-SGG	SOCKET I.C. 14 PIN	XU23	25
	1	1	1	1	55322	ICD-316-SGG	SOCKET I.C. 16 PIN	XU1	26
	1	1	1	1				XK3	
	2	2	2	2	04221	670-0196	SOCKET DIP	XK3,4	27
	2	2	2	2	12300	35C620	COVER, DUST, SNAP-ON		28
	2	2	2	2	06383	MLSS-100-25-B	HEADER 25 PIN	J1,2	30
	2	2	2	2					31
	2	2	2	2	70903	8021-100	WIRE, BUS, 22 AWG	WI-6	32
	2	2	2	2				WI-2	
	2	2	2	2		NAS-703-24UC-XX	WIRE, INSULATED, 24 AWG	WI-7	33
	2	2	2	2		TFT-250/22	SLEEVEING, 22 AWG		34
	2	2	2	2		8021-100	WIRE BUS 22 AWG	WI	35
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**10.0 WARRANTY PROVISIONS, RETURN PROCEDURE
MALFUNCTION REPORT, AND USER'S
COMMENT FORM**

**WARRANTY FOR 9001HA/9010HA/9020HA/
9025HA/9040HA/9075HA SERIES
AND 8001H/8010H/8020H SERIES
TRAVELING-WAVE TUBE AMPLIFIERS**

1. Traveling-wave tube amplifiers sold by Hughes Electron Dynamics Division are warranted to the original Buyer to meet the then current published specifications, drawings and/or such modifications thereof as Buyer and Seller have agreed to in writing and to be free from defects in workmanship and materials. Seller's entire warranty obligation is limited to making adjustments by repairing, replacing, or refunding the purchase price of any product that fails to meet this warranty and that is returned to Seller, as provided below, within one (1) year from date of first shipment by Seller. Replacement, repairs, or adjustments under this warranty shall not reinstate the warranty set forth herein. Under all circumstances, the warranty will expire not later than one (1) year after such first shipment. Adjustments will be made based on the period of time the unit is at Hughes EDD for repair.
2. Adjustment will not be allowed for products that have been subjected to abuse, improper application or installation, alteration, accidental or negligent damage in use, storage, transportation, or handling. Alteration or removal of serial number or identification marking voids the warranty.
3. Seller shall have the right of final determination as to the following: (a) existence and cause of a defect, (b) whether adjustment will be allowed, and (c) if allowed, whether adjustment will be by repair, replacement, or refund. When adjustment is not allowed, a reasonable charge will be made to Buyer to cover Seller's cost of inspection and handling.
4. In the event Seller determines that any product claimed to be defective is not subject to the warranty provisions set forth herein, Buyer will be notified that product is not subject to adjustment. Unless the Buyer furnishes disposition instructions for the product within thirty (30) days after such notification, Seller may return the product "as is" to Buyer, transportation collect.
5. In returning products under this warranty, Buyer shall comply with Warranty Return Procedure set forth on the reverse of this page. Buyer in all cases will obtain and comply with Seller's packaging and shipping instructions. Buyer will pay for packing, transportation, and transit insurance costs for returned products. Credit for transportation and transit insurance charges within the United States will be issued by Seller if adjustment is allowed. When adjustment is not allowed, products will be returned to Buyer transportation collect.
6. THERE ARE NO WARRANTIES THAT EXTEND BEYOND THE DESCRIPTION ON THE FACE OF THIS CONTRACT. Seller shall not be liable for consequential damages. No change in this warranty shall be binding upon Seller unless it shall be in writing signed by duly authorized representatives of Seller.

WARRANTY RETURN PROCEDURE FOR USE BY CUSTOMER

1. Please review terms of purchase and date of shipment to determine whether product is warranted and still within the warranty period and hours of operation. Adjustment cannot be made for products out of warranty.
2. If the product is subject to warranty, telephone, write, or wire Hughes as noted below for instructions before returning the product:

**HUGHES ELECTRON DYNAMICS DIVISION
MARKETING DEPARTMENT
3100 W. LOMITA BOULEVARD
P.O. BOX 2999
TORRANCE, CALIFORNIA 90509-2999
TELEPHONE: (213) 517-6162**

Product malfunctions should be reported to the Marketing Department at the earliest possible time, since there are many occasions when technical assistance may eliminate the need for returning products or can prevent product damage. If it is deemed necessary to return the product for inspection, Marketing will provide instructions for return and, if required, a malfunction report form. All "Customer Material Returns" require a malfunction report.

3. Malfunction reports are normally supplied with all equipment as part of the operations manuals. Additional copies are available from Hughes Marketing Department. Please give all the data requested and fully describe what occurred at the time of failure, carefully noting the operating conditions and total time the product was in use.
4. Repack the product carefully in the same manner it was originally packaged, preferably using the original shipping carton and packaging material. Pack the completed "Malfunction Report" with the product. Ship product prepaid to Hughes by air freight to minimize potential in-transit damage. If adjustment is allowed, Hughes will reimburse you for air freight transportation costs within the confines of the forty-eight contiguous states.
5. Hughes will advise your company of its findings as to warranty consideration at the earliest possible time. The prompt return of all information required above will be appreciated to expedite this procedure.



ELECTRON DYNAMICS DIVISION

MALFUNCTION REPORT MICROWAVE SUBSYSTEM

Please read Warranty Return Procedure before completing this form.

Model No. _____ Serial No. _____ Date Received _____
Date Returned _____

1. Describe malfunction: _____

2. What is the total approximate number of operating hours: _____
3. Describe status indicators after the malfunction _____

4. Describe environmental conditions (altitude, shock, vibration, high or low ambient temperatures) other than normal handling to which the amplifier has been subjected: _____

5. Conditions prior to failure: Line Voltage _____ RF Drive _____
RF Power Out _____ Helix Current _____
6. Conditions after failure: Line Voltage _____ RF Drive _____ RF Power Out _____
7. If unit failed catastrophically, note: _____
(a) Indications of electrical failure _____
(b) Indications of mechanical failure _____
8. List any system elements, other than the subsystem, that malfunctioned prior to or simultaneously with the unit failure: _____

9. Describe previous servicing of instrument: _____

10. Other Comments: _____

This report must be completed and accompany all units returned to Hughes Electron Dynamics Division for action under any warranty clause.

Signed _____
Position _____
Company _____
Address _____
Date _____
Phone (____) _____ Ext _____

USER'S COMMENT FORM

8000H/9000HA MICROWAVE AMPLIFIER VOLUME 1

March 1987

Your comments are an important input to future revisions of this manual.

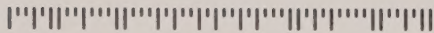
HUGHES AIRCRAFT COMPANY will use and distribute any information that you supply in any way it believes appropriate without incurring any obligation whatever. You may, of course, continue to use the information you supply.

Please use this form for comments on the text of this manual only. Refer any technical questions to the HUGHES Customer Service Hot Line. Telephone (213) 517-5337.

Section: _____

Paragraph: _____

Comments: _____



TORRANCE, CA 90509-2999

P.O. BOX 2999

HUGHES ELECTRON DYNAMICS DIVISION
MARKETING DEPARTMENT/HELIX TWAS

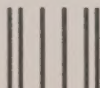
HUGHES AIRCRAFT COMPANY

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BUSINESS REPLY MAIL

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES



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